A
QE81
.A15
no.48
c.2

AUBURN UNIVERSITY
LIBRARY

AUBURN UNIVERSITY
INSTRUCTION
FOR THE ADVANCEMENT OF SCIENCE AND ARTS
ESTABLISHED 1856
RESEARCH EXTENSION

A
QE81
.A15
no.48
c.2

NON CIRCULATING

.en
.g.
CAT.2-

GEOLOGICAL SURVEY OF ALABAMA

WALTER B. JONES, STATE GEOLOGIST (ON LEAVE)

BULLETIN 48

NOTES ON DEPOSITS OF SELMA AND RIPLEY AGE IN ALABAMA

BY

WATSON H. MONROE

LIBRARY
AUG 18 1960
AUBURN UNIVERSITY

UNIVERSITY, ALABAMA

1941

GEOLOGICAL SURVEY OF ALABAMA

WALTER B. JONES, STATE GEOLOGIST (ON LEAVE)

BULLETIN 48

NOTES ON DEPOSITS OF SELMA AND RIPLEY AGE IN ALABAMA

BY

WATSON H. MONROE

UNITED STATES GEOLOGICAL SURVEY

AUBURN UNIVERSITY LIBRARY AUBURN, ALABAMA

UNIVERSITY, ALABAMA

1941

WETUMPKA PRINTING CO.
Printers and Publishers
Wetumpka, Ala.
1941

A
QE81
.A15
no.4
c.
AUG 18 '60
CONNELL

LETTER OF TRANSMITTAL

University, Alabama

March 17, 1941

Honorable Frank M. Dixon,
Governor of Alabama,
Montgomery, Alabama.

Sir:

I have the honor to transmit herewith the manuscript of a report entitled "Notes on Deposits of Selma and Ripley Age in Alabama" by Watson H. Monroe, of the United States Geological Survey. It is requested that it be printed as Bulletin 48 of the Geological Survey of Alabama.

Respectfully,

STEWART J. LLOYD

Asst. State Geologist

TABLE OF CONTENTS

	Page
PREFACE	9
ABSTRACT	11
INTRODUCTION	13
HISTORICAL REVIEW	15
GENERAL FEATURES OF THE UPPER CRETACEOUS FORMATIONS IN ALABAMA	23
PHYSICAL GEOGRAPHY	29
Major divisions	29
Black Prairie belt	30
Chunnennuggee Hills	31
Chunnennuggee Ridge	35
Sand Fort cuesta	35
Enon cuesta	36
Cowikee prairie	40
High Ridge cuesta	40
Lapine cuesta	42
Southern Red Hills	42
Troy cuesta	42
Major streams	43
STRUCTURE	46
STRATIGRAPHY	48
Selma chalk	48
Name	48
Lower marly member	48
Areal extent	48
Lithologic character	49
Thickness	55
Stratigraphic relations	55
Physiographic expression	57
Arcola limestone member	58
Name	58
Areal extent	58
Lithologic character	58
Thickness	63
Stratigraphic relations	63
Physiographic expression	63

TABLE OF CONTENTS—Continued

	Page
STRATIGRAPHY—Continued.	
Selma chalk—Continued	
Demopolis member	64
Name	64
Areal extent	65
Lithologic character	65
Thickness	69
Stratigraphic relations	70
Physiographic expression	72
Blufftown formation	73
Name	73
Areal extent	74
Lithologic character	75
Thickness	86
Stratigraphic relations	86
Physiographic expression	88
Cusseta sand	89
Name	89
Areal extent	89
Lithologic character	91
Thickness	99
Stratigraphic relations	99
Physiographic expression	101
Ripley formation	102
Name	102
Areal extent	103
Lithologic character	104
Thickness	125
Stratigraphic relations	126
Physiographic expression	127
BIBLIOGRAPHY	130
INDEX	139

LIST OF ILLUSTRATIONS

Page

Plate 1. Geologic map of the Upper Cretaceous formations in Central Alabama .... In Pocket

Plate 2. Physiographic divisions of the area of outcrop of formations of Selma and Ripley age in Alabama .... In Pocket

Figure 1. Diagrammatic section showing stratigraphic relations of Upper Cretaceous formations in Alabama 24

Figure 2. Gently undulating surface of the Black Prairie belt. View toward northwest from sec. 20, T. 19 N., R. 5 E., Hale County 30

Figure 3. Small mesa capped by limestone layers of the Arcola limestone member of the Selma chalk. North side of U. S. Highway 80 a mile west of Browns, Dallas County 31

Figure 4. Large bald spot exposing the Demopolis member of the Selma chalk. East side of U. S. Highway 43 in sec. 32, T. 18 N., R. 3 E., Marengo County 32

Figure 5. Conecuh Falls at east side of Union Springs, Bullock County 39

Figure 6. Choctaw Bluff on the Black Warrior River, Greene County 50

Figure 7. The Arcola limestone member of the Selma chalk, 5.2 miles north of Uniontown, Perry County 59

Figure 8. Hatchs Bluff on the Black Warrior River, sec. 3, T. 18 N., R. 3 E., Hale County 61

Figure 9. The Demopolis member of the Selma chalk at Jones Bluff on the Tombigbee River at Epes, Sumter County 66

Figure 10. Bluff on left bank of the Chattahoochee River at the site of old Blufftown, Stewart County, Georgia 76

Figure 11. Ripley formation thrust over Prairie Bluff chalk by a reverse fault, sec. 10, T. 19 N., R. 2 W., Sumter County 106

Figure 12. Contact of the Selma chalk and the overlying Ripley formation, left bank of the Tombigbee River in sec. 11, T. 17 N., R. 1 E., Marengo County 109

Figure 13. Contact of the Ripley formation and the overlying Prairie Bluff chalk, sec. 7, T. 11 N., R. 24 E., Bullock County 118

Figure 14. Sandy limestone at the top of the Ripley formation near old Alexanders Landing on the Chattahoochee River in sec. 9, T. 9 N., R. 29 E., Barbour County 122

Figure 15. Contact of the Ripley formation and the overlying Providence sand on White Oak Creek, sec. 16, T. 9 N., R. 29 E., Henry County 124

PREFACE

Mr. Monroe's work on the Cretaceous of Alabama has been done entirely under the direction of the United States Geological Survey. The Director of the Federal Survey has graciously permitted the Geological Survey of Alabama to publish the results of Mr. Monroe's studies and we wish at this time to express our appreciation for this cooperation.

Stewart J. Lloyd

Assistant State Geologist

Geological Survey of Alabama

NOTES ON DEPOSITS OF SELMA AND RIPLEY AGE IN ALABAMA[1]

by Watson H. Monroe[2]

Abstract

The Upper Cretaceous deposits of Alabama appear at the surface in a crescentic belt comprising an area of roughly 10,000 square miles that passes through the central part of the State. In the western part of Alabama the series includes, in ascending order, the Tuscaloosa formation, the Eutaw formation, the Selma chalk, the Ripley formation, and the Prairie Bluff chalk. In the eastern part of the State the chalk formations merge laterally into sand and clay, and the section in that region consists of the Tuscaloosa formation, the Eutaw formation, the Blufftown formation, the Cusseta sand, the Ripley formation, and the Providence sand.

In the present paper only the formations of Selma and Ripley age are described. The Selma chalk is divided into three members: an unnamed lower marly member that includes the typical beds exposed at Selma, the Arcola limestone member, and the Demopolis member. The lower marly member and the Arcola limestone member of the Selma merge and intertongue with the Blufftown formation. The Demopolis member merges and intertongues with the Cusseta sand. The Ripley formation consists of chalky sand in the western part of Alabama and of gravel, sand, clay, and limestone in eastern Alabama.

The fossils of the Upper Cretaceous fall into two great faunal zones known throughout the Atlantic and Gulf Coastal Plain, the *Exogyra ponderosa* zone below and the *Exogyra costata* zone above. The *Exogyra ponderosa* zone in Alabama includes the upper half of the Tombigbee sand member of the Eutaw formation; the lower marly member, the Arcola limestone member, and the lower two thirds of

[1]Published by permission of the Director, Geological Survey.
[2]United States Geological Survey.

the Demopolis member of the Selma chalk; the Blufftown formation; and all but the upper 50 feet or so of the Cusseta sand. Within the *Exogyra ponderosa* zone are three smaller faunal zones: the *Ostrea elegantula* zone, the *Diploschiza cretacea striata* zone, and the *Diploschiza cretacea* zone.

The *Exogyra costata* zone includes the upper third of the Demopolis member of the Selma chalk, the Ripley formation, the Prairie Bluff chalk, the upper 50 feet or more of the Cusseta sand, and the Providence sand. The lower third of the *Exogyra costata* zone consists of a smaller faunal zone, the *Exogyra cancellata* zone, which forms the upper third of the Demopolis member in Sumter County and the equivalent beds of the Demopolis member, the Cusseta sand, and the Ripley formation farther east.

The belt of outcrop of the formations of Selma and Ripley age is entirely within the eastern Gulf Coastal Plain. The belt of outcrop of the Selma chalk is coincident with the Black Prairie belt. The Blufftown formation, the Cusseta sand, the Ripley formation, the Prairie Bluff chalk, and the Providence sand consist of more resistant strata that give rise to the Chunnennuggee Hills. The lower part of each of the sandy formations gives rise to a cuesta for which the following names are proposed: Sand Fort cuesta for the Blufftown formation, Enon cuesta for the Cusseta sand, High Ridge cuesta for the Ripley formation, and Lapine cuesta for the Providence sand. The basal beds of the Clayton formation give rise to another cuesta within the Southern Red Hills district for which the name Troy cuesta is proposed. A small area of prairie, the Cowikee prairie, is developed in Barbour County because deep incision of the South Fork of Cowikee Creek has exposed the lower marly member of the Selma chalk.

INTRODUCTION

In 1937 Dr. Walter B. Jones, the State Geologist of Alabama, proposed that the U. S. Geological Survey and the Geological Survey of Alabama make a cooperative investigation of the Upper Cretaceous deposits of Alabama. Funds were set aside by the Alabama Survey to be matched by the Federal Survey and Messrs. L. W. Stephenson and W. H. Monroe were assigned the task of preparing a new geologic map and report on the outcropping Upper Cretaceous rocks. Unfortunately the State funds had to be withdrawn, but the Federal Survey decided to begin the investigation in the hope that the State later would be able to cooperate more fully.

Accordingly in October 1937 I began tracing the subdivisions of the Cretaceous, previously determined in Mississippi, eastward through Alabama, and with brief interruption, this work was continued through November. During this period I was accompanied part of the time by Miss Winnie McGlamery of the Alabama Survey and F. Stearns MacNeil of the Federal Survey. In March 1938 work in the eastern part of the State was resumed and in April L. W. Stephenson joined me in formulating conclusions, later published (96)[a], about the stratigraphic relations in that part of the State.

During this early investigation evidences of reverse faulting were seen in the banks of Tombigbee River below Demopolis, Marengo County, and along U. S. Highway 11 north of Livingston, Sumter County. In 1939 the U. S. Geological Survey authorized mapping the Epes quadrangle to study these faults and to prepare an accurate geologic section of outcropping formations as an aid to economic geologists interested in the Cretaceous deposits of Alabama. G. R. Pierce assisted in the work during August and

[a]Numbers in parentheses refer to papers listed in the bibliography.

September and Vija Sreshthaputra during the first half of December. Early in 1940, Dr. Stewart J. Lloyd, Assistant State Geologist, requested a preliminary report on some part of the Cretaceous of Alabama. This required an additional month of field work which was done in June and July with Andrew Brown as assistant. The geologic map (pl. 1) was prepared largely on the basis of that work but the boundaries of the Tuscaloosa formation and the Prairie Bluff-Midway contact are copied directly with only slight modifications from the State geologic map (77).

Invaluable help was given me by field assistants and colleagues of the Geological Survey, particularly L. W. Stephenson, C. S. Ross, and P. G. Nutting, who have identified fossils and clays. The courtesies of the staff of the Alabama Survey have far exceeded the demands of ordinary cooperation. L. G. Brackeen of the Alabama Department of Agriculture permitted me to use his unpublished soil map of Elmore County. Many workers connected with the oil industry have helped, particularly Willard Payne and Ray Claiborne of the California Company who showed me previously unknown outliers of Selma chalk in Hale County. My wife and daughter have assisted materially both in reading proof and in preparation of the index.

As this report and map are based on a strictly reconnaissance survey of the large area in Alabama that contains outcrops of rocks of Upper Cretaceous age it is evident that much additional work must be done before the intricacies of the stratigraphy and structure can be satisfactorily solved. A particularly puzzling problem is the apparent overlap of the entire Ripley formation by the Providence sand in the vicinity of Mount Andrew, Barbour County. Any additional work in that region by other geologists will be welcomed.

Other areas in which work is especially needed include the strip of faulting in Sumter and Marengo Counties, and the small highly faulted area near Wetumpka, Elmore County. More information on the manner in which the members of the Selma intertongue to the east with the sandy formations of the Chattahoochee River region is needed to clarify knowledge of the stratigraphy.

HISTORICAL REVIEW

Nearly a hundred papers dealing with the deposits of Selma and Ripley age in Alabama are listed in the bibliography at the end of this report, but in a preliminary paper, such as this, space does not permit mention and detailed description of each one. Only those papers that marked some advance of knowledge or change in classification of the deposits are mentioned here. The bibliography lists all papers dealing with this region that have come to my attention, and is in itself a historical review of the advance of knowledge of the Selma and Ripley formations and their equivalents.

The first reference to the presence of Cretaceous rocks in Alabama was made by Morton in 1829 (1), and in later papers (2, 6, and 7) he mentioned specific fossiliferous localities on the Alabama and Black Warrior Rivers.

In 1833 Dr. R. W. Withers, who lived at Erie on the Black Warrior River, published a good description of the Black Prairie belt, and described for the first time the limestone now known as the Arcola limestone member of the Selma chalk.

In 1847 Michael Tuomey was appointed professor of geology at the University of Alabama and was authorized "to spend such portions of his time, not exceeding four months in each year, in exploring the State in connection with his proper department, as the Trustees may consider for the advantage of the State," and in 1848 the General Assembly appointed him State Geologist. In 1850 he published his first biennial report (12) in which he showed that the artesian wells drilled in the prairie obtain water from the formation (now known as the Eutaw) exposed at Finch's Ferry on the Black Warrior River near Eutaw, Greene County, and explained the relations of these sands to the rotten limestone (Selma chalk) by describing the section at Choctaw Bluff (sec. 26, T. 21 N. R. 2 E.), Greene County; he described the "bored rock" (Arcola limestone member of the Selma chalk) and traced it from Arcola (sec. 4, T. 18 N., R. 3 E., Hale County) west through Greene County; he ascribed the lack of trees on the prairie to frequent burning by Indians and later by white settlers; and he included an interesting table of artesian wells and commented on an increase

in temperature of 1° F. for each 55 feet in depth. In his second biennial report (20), published posthumously and edited by J. W. Mallet, he suggested that the rotten limestone (Selma) at Jones Bluff (Epes, Sumter County) be used for hydraulic lime or cement. It is interesting that this same bed is now used in the manufacture of Portland cement at Demopolis. He also described the geology of the Chunnennuggee Ridge country in the area of Tuskegee, Eufaula, and Columbus, Ga. In an appendix to this report Thornton (21) described many localities in eastern Alabama, but made no attempt to correlate them with deposits in western Alabama. The geologic map accompanying the second biennial report is much more like the present map than the one published with the first report, the only serious error being a miscorrelation of the weathered Eutaw and Tuscaloosa as "post-Tertiary".

At about this same time Alexander Winchell was teaching at Eutaw and described before the American Association for the Advancement of Science the geology of Choctaw Bluff on the Warrior River (14) and the general features of the geology of the Coastal Plain of Alabama (16). In the second paper he divided the Cretaceous beds of Alabama into the following units in ascending order: (a) sand and clay, which he thought might be Triassic (now the Tuscaloosa formation and the main body of the Eutaw formation); (b) loose sand (the upper part of the Tombigbee sand member of the Eutaw formation); (c) concrete sand (the basal 2 to 5 feet of the Selma chalk; (d) rotten limestone (Selma chalk); (e) white sand (Ripley formation); and (f) Prairie Bluff limestone (Prairie Bluff chalk and possibly the basal bed of the Midway group).

In 1860 Hilgard (26) published his classic report on the geology of Mississippi, and in 1871 he (31) described the geology of the Mississippi Embayment and divided the Upper Cretaceous deposits of Mississippi and Alabama into the Coffee or Eutaw group, the Rotten limestone group, and the Ripley group. He correlated these units with formations in New Jersey and the Western Interior.

The Geological Survey of Alabama was inactive from the death of Professor Tuomey in 1857 until 1873 when Dr. Eugene Allen Smith was appointed State Geologist. Since 1873 it has been one of most active State Surveys in the United States, largely

because of the impetus given geological exploration in the State by Dr. Smith. The first of his many reports dealing with the Coastal Plain was on the agricultural features of the State, issued in 1883 (36) which was apparently much the same material he included in his report for the Tenth Census on the cotton production of the State (37) in which he divided the Southern Division (Coastal Plain) of Alabama into 6 physiographic districts. The second of these, the Central or Upper Prairie region, includes the area described in the present paper and was subdivided into the Black belt, the Hill prairies and Chunnenugga[a] Ridge, and the Blue Marl lands.

In 1884 Smith discovered phosphate-bearing sand at Hamburg, Perry County, and later at other places in the Upper Cretaceous and the basal Midway. He announced this discovery in several short notes and reports (39, 40, 41, and 42) culminating in Bulletin 2 of the Alabama Survey (49).

In 1887 Smith and Johnson published their report on the "Tertiary and Cretaceous strata of the Tuscaloosa, Tombigbee, and Alabama Rivers" (43), which first gave detailed information on the geology of western Alabama. The bulletin is based primarily upon data obtained in 1883 on a trip, in which the Alabama Survey and the U. S. Geological Survey cooperated, down the Tuscaloosa (Black Warrior) and Tombigbee Rivers to Mobile and thence up the Alabama River to Prairie Bluff, supplemented by additional data obtained in later field trips by Dr. Smith and his associates. In this bulletin Smith and Johnson proposed the name Tuscaloosa formation and divided the overlying Upper Cretaceous rocks in western Alabama into the Eutaw formation, the Rotten limestone, and the Ripley formation. The units were defined much the same as they are in the present report, except that the Rotten limestone (now called the Selma chalk) included the sandy chalk in western Alabama now included in the Ripley formation and the overlying chalk now called the Prairie Bluff chalk, and their Ripley formation included the eastern part of the Prairie Bluff chalk and the lower part of the Midway group.

---

[a]Harper (67, p. 91) discusses variations in the spelling of this name and recommends "Chunnennuggee", which will be used in this report except in quotations.

In 1891 Langdon (45) published a detailed section of the strata of the Mesozoic and Cenozoic exposed on the Chattahoochee River. This was copied with more or less added information in publications of the Geological Surveys of Georgia (47) and Alabama (50). The parts of Langdon's section between the top of the Eutaw formation, as it is now limited, and the Tertiary are copied in the present report, for no more accurate description of these strata has been published since. Langdon attempted to correlate the strata on the Chattahoochee River with the formations of western Alabama previously described by Smith and Johnson (43), but he was seriously hampered by lack of paleontologic data.

In 1894 Smith, Johnson, and Langdon (50) published their classic "Report on the geology of the Coastal Plain of Alabama" in which revisions of earlier reports (43, 45, and 49) and a section describing the geology of each county were included. In this report the Tuscaloosa formation was assigned to the Upper Cretaceous and the Rotten limestone was given the co-name Selma chalk. Their report is still the main reference work for geological investigations in the Coastal Plain of Alabama.

In 1895 Smith (51) published the first of several papers on the resources for the manufacture of Portland cement. In 1903 Smith (53) proposed that the Selma chalk be divided into three divisions: The upper or Portland division containing 25 percent or more of clayey impurities (including what is now considered the upper part of the Selma chalk, a part of the Ripley formation, and a part of the Prairie Bluff chalk); the middle or Demopolis division containing less than 25 percent of clay (including what is now considered most of the Demopolis and Arcola members of the Selma chalk); and a lower or Selma division like the upper division composed of clayey limestone or calcareous clay (including all but the basal part of the lower marly member of the Selma of the present report). He considered only the Demopolis member satisfactory for the manufacture of Portland cement. Other papers on cement materials by Smith (54, 55, 59, and 68) and by Eckel and Crider (57) were published in later years and include numerous chemical analyses.

In 1904 Smith (56) published an account of the water resources of the Coastal Plain of Alabama in which many well logs were included as a part of numerous descriptions of artesian wells

in the State. This paper was followed by a supplemental account (58) of the underground waters published in 1905, and all the available data on the underground water resources of the State were issued as a report of the Alabama Survey (60) in 1907.

In 1909 Veatch (62) made the first attempt to divide the Ripley formation of the Chattahoochee region into smaller units. He proposed that the formation be divided into the following members: Upper unconsolidated sand (Providence), 150 feet; upper marl (Renfroes), 500 feet; middle unconsolidated sand (Cusseta), 250 feet; and lower marl (Blufftown), 200 feet. In the present classification of the U. S. Geological Survey each of Veatch's members is considered a formation, although the limits are not exactly those proposed by him; his Renfroes marl is the eastward extension of the Ripley formation of Mississippi and the name Ripley is used, therefore, rather than Renfroes.

In 1911 Stephenson (65) published his report on the geology of the Cretaceous deposits of Georgia in which he redefined the units used in previous reports, and was able to make many accurate correlations with formations in other states. His classification of deposits on the Chattahoochee River differed from that now in use as follows: his basal beds of the Eutaw formation are now believed to represent the Tombigbee sand member of the Eutaw formation; his typical Eutaw and Tombigbee sand member of the Eutaw are now called the Blufftown formation and are believed to represent the lower third of the Selma chalk up to and including the Arcola limestone member; his Cusseta sand member of the Ripley formation and the equivalent fossiliferous beds of his typical Ripley formation constitute the Cusseta sand; his Providence sand member of the Ripley formation and the equivalent fossiliferous beds assigned to the typical Ripley are now treated as a separate formation, the Providence sand, equivalent to the Prairie Bluff chalk.

In 1913 Harper (67) described the physiography of Alabama and proposed names for the physiographic divisions of the Cretaceous belt. His terminology, with a few modifications, is used in the present report.

The Cretaceous deposits of the eastern Gulf region were defined and correlated by Stephenson (69) in 1914, and the importance of the zones of *Exogyra ponderosa, E. costata,* and *E. can-*

cellata (first described in that paper as a variety of *E. costata*) in establishing relative ages was brought out. The check lists of fossils published in this paper are of great value to geologists in the eastern Gulf region, although many of the fossil names have been changed by Stephenson's later work.

The concept of intertonguing of formations was formulated by Stephenson (71) in 1917 and the Prairie Bluff tongue of the Selma chalk, formerly treated as a part of the Ripley formation, was named. The Prairie Bluff tongue is now a part of the Prairie Bluff chalk.

Cleland (75) in 1920 suggested that the Black Prairie belt may be a Pleistocene peneplain. His proposal is discussed in detail in the part of this report describing the physical geography of the region and need not be given here.

The Geological Survey of Alabama in 1926 published Special Report 14 on the Geology of Alabama, in which the Mesozoic (Upper Cretaceous) rocks were described briefly by Stephenson (77). The geologic map (pl. 1) accompanying the present report is based on the map of Alabama published in Special Report 14, but redefinition of some of the formations has caused numerous changes in the eastern part of the State. In the map accompanying the present report the boundaries of the Tuscaloosa and the Cretaceous-Tertiary boundary are copied from the earlier map with only minor changes.

In 1928 Stephenson (79) suggested correlations of the Alabama Cretaceous formations with the European stages, and showed that in terms of the Texas section the Austin chalk is equivalent to the lower, typical beds of the Eutaw formation, the Taylor marl is represented by the Tombigbee sand member of the Eutaw formation and the lower two-thirds of the Selma chalk, and the Navarro group is equivalent to the upper third of the Selma chalk and the Ripley formation. In recent years he has changed this correlation and now believes that the lower part of the Selma and the Tombigbee sand member of the Eutaw are of Austin rather than of Taylor age (100).

Adams (80) suggested in 1929 that after an emergence of the Coastal Plain from the sea at the end of the Miocene the streams flowed in parallel lines to the Gulf. Downwarping in the south-

western part of the State or upwarping of the Chattahoochee region caused diversion of the streams to the southwest and the capture of parts of the Alabama River at Selma and Montgomery. The great gravel deposits of the Citronelle formation were laid down by the Alabama River as changed by the stream capture and at this time the lowland on the Eutaw formation and the Selma chalk was developed. He believed that the streams heading south of the Chunnennuggee Ridge established their southwestward courses after the relative downwarp in southwestern Alabama.

Semmes' report (81) on Oil and Gas in Alabama includes a good review of the geology and geography of the rocks of the Coastal Plain as well as a discussion of the possibility of finding oil and gas in the various counties. Numerous well logs make this volume a particularly useful reference work.

In 1933 Stephenson (86) traced the zone characterized by *Exogyra cancellata* 2,500 miles from New Jersey to Mexico and mentioned several localities in Alabama. He showed the great value of this species as an index fossil in mapping stratigraphy and making long-range correlations.

The value as horizon markers of the small bivalves of the genus *Diploschiza* was pointed out by Stephenson in 1934 (88) and 1935 (91). Since the publication of his papers the zones have been traced much farther than he indicated and it has been found that the zones are restricted to thin bands of chalk, traceable for long distances.

The Prairie Bluff chalk was designated a formation distinct from the Selma chalk by Stephenson and Monroe (94) in 1937, and a reclassification of the Upper Cretaceous deposits of Alabama was proposed by them (96) in 1938. The lower part of the Selma chalk was shown to merge and intertongue eastward into the Blufftown formation, the middle part into the Cusseta sand, and the upper part into the Ripley formation. The Prairie Bluff chalk was shown to merge gradually eastward into the Providence sand. The Arcola limestone member of the Selma chalk was named and described. Disconformities between the Eutaw formation and the Selma chalk (in the east the Blufftown formation), between the Blufftown formation and the Cusseta sand, between the Prairie Bluff chalk (in the east the Providence sand) and the underlying Selma chalk or Ripley formation, and one within the Selma chalk just

above the Arcola limestone member were described, and their relative importance discussed. In the present paper the same classification is used except that the upper sandy part of the Selma in the western part of Alabama, then said to be equivalent to the Ripley formation, is now treated as a part of the Ripley formation, and the lower limit of the Ripley formation in eastern Alabama is now placed at a slightly higher stratigraphic position.

In 1940 Munyan (99) described bentonite from 6 localities in the lower part of the Selma chalk in Hale and Dallas Counties.

GENERAL FEATURES OF THE UPPER CRETACEOUS FORMATIONS IN ALABAMA

The Upper Cretaceous deposits of Alabama appear at the surface in a crescentic belt comprising an area of roughly 10,000 square miles that passes through the central part of the State. The belt is 40 to 50 miles wide and extends from the Chattahoochee River west and northwest to the Mississippi State line. (See pl. 1). The deposits, chiefly of marine origin, consist of stratified gravel, sand, clay, marl, chalk, and limestone and have an estimated total thickness of 2,300 feet. The bedding planes dip to the west in the northwestern part of the State, to the southwest in the west-central part, to the south in the central part, and to the southeast in the Chattahoochee River region at rates that range from 30 to 40 feet to the mile. Locally steeper dips accompany faulting. In the western part of Alabama the series have been divided on the basis of lithologic character, in ascending order, into the Tuscaloosa formation, the Eutaw formation, the Selma chalk, the Ripley formation, and the Prairie Bluff chalk. In the eastern part of the State the chalk formations merge laterally into sand and clay, so that the section in that region consists of the Tuscaloosa formation, the Eutaw formation, the Blufftown formation, the Cusseta sand, the Ripley formation, and the Providence sand. The stratigraphic relations of these formations are shown in figure 1.

The Tuscaloosa formation rests unconformably on an eroded surface of ancient rocks that range in age from pre-Cambrian in eastern Alabama to Pennsylvanian in western Alabama. In some parts of the outcrop the top of the underlying rocks has been eroded to a uniform surface resembling a peneplain; in others, notably in the northwestern corner of Alabama, this surface is irregular, having an observed relief of more than 100 feet. The sediments composing the formation consist of sand, clay, gravel, and lignite and are generally irregularly bedded. They were laid down in part in a shallow marginal sea, in part in bordering bays, lagoons, and marshes, and in part in the deltas of streams. Plant fossils are common in some parts of the formation, but the only animal fossils thus far found are obscure prints of shells of long-ranging genera in clays near Maplesville, Chilton County.

The Eutaw formation rests with marked unconformity on the Tuscaloosa formation. The lower part of the Eutaw contains

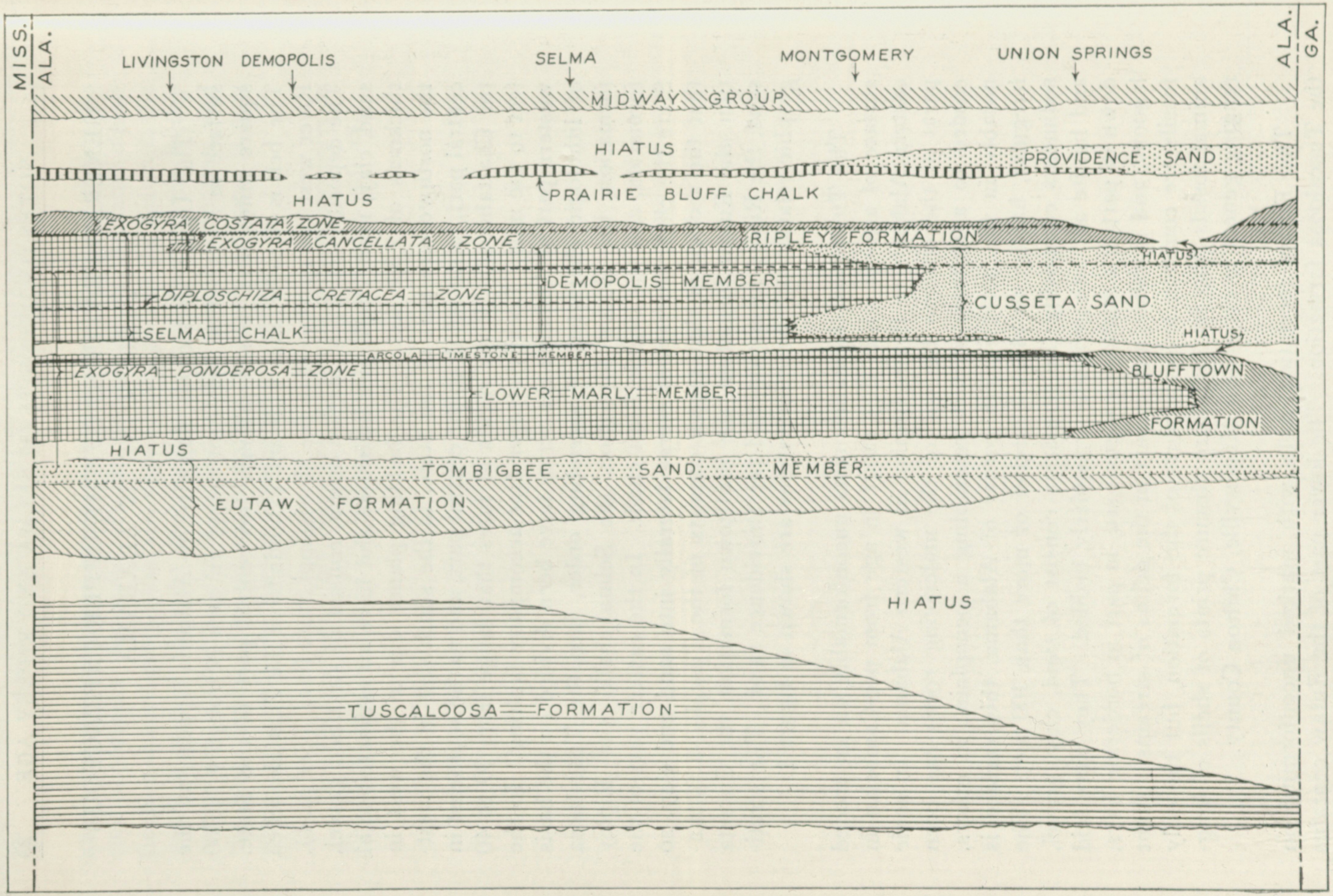

Fig. 1.—Diagrammatic section showing stratigraphic relations of Upper Cretaceous formations in Alabama,

much fine gravel that rests on finer sediments of the underlying Tuscaloosa formation. Higher parts of the formation consist of highly crossbedded glauconitic sand and thinly laminated sand and clay. The upper part, called the Tombigbee sand member, consists of massive, but in places somewhat cross-bedded, fine glauconitic sand containing numerous fossil shells, mostly of the oyster family. In the eastern part of Alabama the lower part of the Eutaw formation is missing and fine yellow sand and silt, believed to be equivalent to the Tombigbee sand member, rest directly on the Tuscaloosa formation. A notable feature of this sand, especially in Russell County, is a bed as much as 100 feet thick made up almost solidly of the shells of *Ostrea cretacea.*

The Selma chalk rests disconformably on the Eutaw formation from the Mississippi State line southeast and east to Macon County, where the lower part of the Selma merges laterally into the lower part of the Blufftown formation. Still farther east the Selma rests conformably on the lower part of the Blufftown formation. The Selma is divided in this report into three members, an unnamed lower marly member that includes the typical beds exposed at Selma, the Arcola limestone member, and the Demopolis member. The relations of these members are shown in the stratigraphic section (fig. 1).

The lower marly member of the Selma chalk in Macon, Bullock, and Russell Counties merges and intertongues with the Blufftown formation. The member is overlain conformably by the Arcola limestone member, composed of alternating layers of pure, hard limestone and soft marl, which also merges into the Blufftown formation in Bullock County. The Arcola member is overlain disconformably by the Demopolis member, which consists of much purer chalk than the lower members. The Demopolis merges and intertongues in Montgomery County with the Cusseta sand.

The Blufftown formation consists at the base of coarse sand and fine gravel overlain by finer sand and clay. It is overlain disconformably by the Cusseta sand, which also consists of coarse sand and fine gravel at the base overlain by finer sand, clay and chalky sand.

The Selma chalk in the west and the Cusseta sand in the east are overlain by the Ripley formation, a generally sandy formation containing some clay and in places hard sandy limestone.

The Ripley formation is overlain unconformably by the Prairie Bluff chalk as far east as Perote, Bullock County, and by the Providence sand east of Perote. The Prairie Bluff chalk consists in the western part of Alabama of hard, brittle chalk, except near Livingston, Sumter County, where the lower and northern parts contain much very coarse sand. The lower part of the formation contains abundant phosphatic internal molds of mollusks, many fossil shells, and a few pebbles and cobbles reworked from underlying indurated beds. Farther east the chalk gradually merges into marl that also contains phosphate, and in which cobbles are more common.

In the western part of Lowndes County the upper part of the Prairie Bluff chalk merges laterally into calcareous fine sand that is assigned to the Providence sand. A long tongue of marl of the Prairie Bluff chalk extends eastward beneath a westward-extending tongue of the Providence sand, but the upper part of the tongue of chalk gradually merges into the sand at successively lower stratigraphic positions toward the east, with the result that the tongue of chalk is very thin in Pike and Bullock Counties. The easternmost point at which material can be assigned to the Prairie Bluff chalk is about 1½ miles east by north of Perote, Bullock County. Farther east in Barbour County the base of the Providence and Prairie Bluff unit of deposition consists of phosphatic sand and pebbles that are included in the Providence sand.

The Providence sand is composed of shallow-water, perhaps non-marine, strata of irregularly bedded fine to coarse sand, fine gravel, and white clay except in down-dip exposures in the deeper valleys, where the formation consists of highly fossiliferous marine sand and sandstone. Parts of the Providence have a remarkable resemblance to some parts of the Tuscaloosa formation. In the western part of Barbour County the Providence sand apparently overlaps the entire Ripley formation and rests on the Cusseta sand.

Evidence of the unconformity between the Ripley formation (below) and the Prairie Bluff chalk and Providence sand (above) consists of borings into the Ripley filled with material from above and a basal conglomerate in the Prairie Bluff and Providence consisting of coarse sand, gravel, phosphatic internal molds of mollusks, and, in places, partly phosphatized cobbles of sandy limestone reworked from the Ripley formation. On the Alabama River the upper beds of the Ripley dip steeply downstream to the south

but the overlying Prairie Bluff chalk has a normal gentle dip, and thus rests on truncated beds of the Ripley formation. The contact here, therefore, is an angular unconformity. As already stated the unconformity appears to be an overlap in Barbour County.

The Prairie Bluff chalk and the Providence sand are overlain unconformably by deposits of the Midway group, which in Marengo County completely overlap the Prairie Bluff and rest on the Ripley formation. In the western part of the State the lower part of the Midway consists of clay (Sucarnoochee clay), but east of Marengo County the lower part of the clay merges into sand, gravel, and limestone of the Clayton formation, which overlies the Providence sand in the eastern part of Alabama.

The Tuscaloosa formation and the lower part of the Eutaw formation contain only scattered, poorly preserved fossils, but shells become abundant in the Tombigee sand member and are common in at least parts of all overlying formations. The fossils of the Upper Cretaceous fall into two great faunal zones known throughout the Atlantic and Gulf Coastal Plain (69), the *Exogyra ponderosa* zone below and the *Exogyra costata* zone above.

The *Exogyra ponderosa* zone in Alabama includes the upper half of the Tombigbee sand member of the Eutaw formation; the lower marly member, the Arcola limestone member, and the lower two thirds of the Demopolis member of the Selma chalk, the Blufftown formation; and all but the upper 50 feet or so of the Cusseta sand. Within the *Exogyra ponderosa* zone are three smaller faunal zones useful in making long range correlations and in mapping stratigraphy in restricted areas: the *Ostrea elegantula* zone, the *Diploschiza cretacea striata* zone, and the *Diploschiza cretacea* zone. The lowest of these zones is characterized by *Ostrea elegantula* (92) a small oyster that in eastern Gulf region has thus far been found only in the Blufftown formation. It has also been collected in Texas and the western interior, indicating a correlation of the lower part of the Blufftown formation with the Blossom sand in Texas, and the upper part of the Mancos shale and the lower part of the Mesaverde formation in New Mexico. The next higher zone is in the lower 50 feet or more of the Demopolis member of the Selma chalk just above the Arcola limestone member; it is characterized by a small pelecypod *Diploschiza cretacea striata* (88). The Arcola limestone below is so easily recognized throughout the region that it is doubtful whether this faunal zone will be used extensively in geologic mapping. The

stratigraphic position of the zone was found only in 1940 and has thus far been traced laterally from Sumter County on the west to the vicinity of Browns, Dallas County, on the east. The highest of the subzones, the *Diploschiza cretacea* zone, occurs in the purest part of the Demopolis member of the Selma chalk. It is characterized by the small pelecypod *Diploschiza cretacea* and the small brachipod *Terebratulina filosa*. The *Diploschiza cretacea* zone has been traced in the eastern Gulf region from Tupelo, Lee County, Mississippi, south and southeast into Alabama, where it occurs in the lower part of Jones Bluff at Epes, Sumter County, thence east through Demopolis in Marengo County and White's Bluff on the Alabama River, to Ada, Montgomery County where it is found in the lower part of an eastward-extending tongue of the Demopolis member. The correlative of this zone in the western Gulf region is characterized by the varietal form *Diploschiza cretacea minor* and by the same brachiopod *Terebratulina filosa*. These fossils have been collected from the Annona chalk and the Pecan Gap member of the Taylor marl in northeastern Texas and from the Anacacho limestone in southern Texas.

In Alabama the *Exogyra costata* zone, the higher of the two major faunal zones, includes the upper third of the Demopolis member of the Selma chalk, the Ripley formation, the Prairie Bluff chalk, the upper 50 feet or more of the Cusseta sand, and the Providence sand. The lower third of the *Exogyra costata* zone consists of a smaller faunal zone, the *Exogyra cancellata* zone, characterized especially by the presence of *Exogyra cancellata* and *Anomia tellinoides*. This smaller zone forms the upper third of the Demopolis member of the Selma chalk in Sumter County and the equivalent beds of the Demopolis and the Ripley formation farther east. East of Montgomery County the zone constitutes the upper part of the Ripley formation. Stephenson (86) has traced the *Exogyra cancellata* zone from New Jersey to Mexico.

On the geologic map (pl. 1) the approximate line of outcrop of the *Diploschiza cretacea* zone is shown by the line D, and the outcrop of the plane dividing the *Exogyra ponderosa* from the overlying *Exogyra costata* (and *Exogyra cancellata*) zone is shown by the line P. The top of the *Exogyra cancellata* zone can be mapped easily, but the time for preparation of the map has been so short that this line cannot be shown at all accurately from available notes.

PHYSICAL GEOGRAPHY

Major divisions

The area underlain by the Upper Cretaceous rocks in Alabama is entirely within the eastern Gulf region of the Coastal Plain. The first attempt to set up physiographic divisions of the Coastal Plain of Alabama was that of Smith (37) who subdivided his Southern Division (Coastal Plain) into the following regions: (a) the Oak and Pine Uplands region (corresponding roughly to the area of outcrop of the Tuscaloosa and Eutaw formations); (b) the Central or Upper Prairie region (corresponding to the area of outcrop of the Selma chalk, Blufftown formation, Cusseta sand, and Ripley formation), which in turn he divided into the Black belt or Canebrake region, the Hill Prairies and Chunnenugga Ridge, and the Blue Marl lands; (c) the Post Oak Flatwoods region (Sucarnoochee clay); (d) Lime Hills or Lower Prairie Region; (e) Long Leaf Pine region; and (f) Alluvial region.

Harper (67, frontispiece) used much the same classification, but divided the belt of outcrop of the Upper Cretaceous rocks into the Central Pine belt, the Black belt, and the Chunnennuggee belt. Semmes (81, fig. 37, pp. 202-205) divided the outcrop area of the Cretaceous into the Fall Line Hills, the Black Prairies, and the Chunnenuggee Ridge. Fenneman (95, pp. 67-72) used the same classification but referred to the Chunnennuggee Ridge as the Ripley cuesta.

In this report a slight revision is proposed of the terminology of the physical features of the area of outcrop of the formations of Ripley and Selma age. The Tuscaloosa and Eutaw belts are not discussed but it may be said that the term "Fall Line hills" is scarcely appropriate inasmuch as the true Fall Line does not extend west or south of the region of outcrop of the metamorphic rocks of the Piedmont Plateau.

It is proposed that the name Black Prairie belt be retained for the area of outcrop of the Selma chalk, but that the area of outcrop of the sandy formations equivalent in age to the Selma, Ripley, and Prairie Bluff formations be designated the Chunnennuggee Hills. (See pl. 2). The old name Chunnennuggee Ridge[a]

---

[a]Harper's spelling (67, p. 91) is used consistently in this report except in quotations of earlier writers.

does not seem appropriate because several distinct ridges are included in this physiographic district, and because the original definition of Chunnennuggee Ridge referred only to the divide between the Alabama drainage to the north and the drainage of the Conecuh and Pea Rivers to the south. The Chunnennuggee Hills consist of a series of distinct cuestas that will be discussed in detail on a later page.

Black Prairie belt

In the western part of Alabama the Black Prairie belt is bounded on the north by the sand hills underlain by the Eutaw formation and on the south by the Chunnennuggee Hills. In the eastern part of Alabama, however, the belt divides into a number of smaller belts that extend to the east into the Chunnennuggee Hills district.

The northern edge of the Black Prairie belt is not sharply distinguishable from the hills to the north because the marl of the Selma laps up on these hills. The change in topography, however, is very noticeable within a short distance when one passes

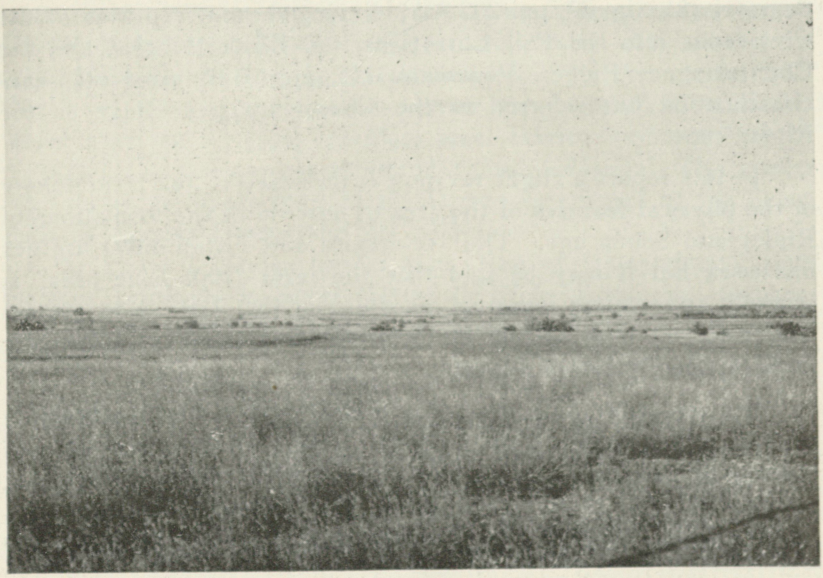

Fig. 2.—Gently undulating surface of the Black Prairie belt. View toward northwest from sec. 20, T. 19 N., R. 5 E., Hale County.

from the prairie to the hills. The southern edge of the belt, on the other hand, is marked by a very sharp change in topography because the northern edge of the Chunnenuggee Hills is a steep slope.

The northern part of the Black Prairie belt is the part usually considered the typical black belt because the marls of the lower marly member of the Selma chalk weather to deep black soil that is a natural grassland. The topography is gently rolling with slopes in the upland away from the major streams ranging from 1 to 10 per cent. The southern edge of this part of the Black Prairie belt is marked by a small cuesta scarp caused by projecting ledges of the Arcola limestone member. A cuesta (Spanish word meaning hill) is a ridge characterized by a steep slope in one direction and a long, gentle slope in the other, with the bedding of the rocks in the ridge approximately parallel to the gentle slope. Cuestas are common features in regions of gently dipping rocks of variable hardness such as the Coastal Plain. The scarp caused by the Arcola limestone member of the Selma chalk is now generally termed by geologists working in the area the Arcola cuesta scarp. This

Fig. 3.—Small mesa capped by limestone layers of the Arcola limestone member of the Selma chalk. North side of U. S. Highway 80 a mile west of Browns, Dallas County.

scarp is most prominent near the major streams in the belt, where it may reach an altitude of 75 feet or more above the lowland to the north, but in the interstream areas it reaches an altitude of 40 feet or more above the lowland. The scarp is readily traceable from the Mississippi State line southeastward and eastward to the western part of Bullock County where it appears to pass into the much higher Enon cuesta of the Chunnennuggee Hills. An interesting feature of the Arcola scarp is the abundance of small mesas caused by outliers of the Arcola limestone (fig. 3).

South of the Arcola cuesta is a belt of flatter country characterized by abundant bald spots of chalk. (See fig. 4). The soil in this region is derived from a purer member of the Selma chalk, the Demopolis member, and is very thin, in many places not more than 3 inches thick. Consequently the soil is eroded away easily leaving the bare chalk exposed. This region is also included in the Black Prairie belt, but the black soils of the more northerly part of the belt are not quite so common.

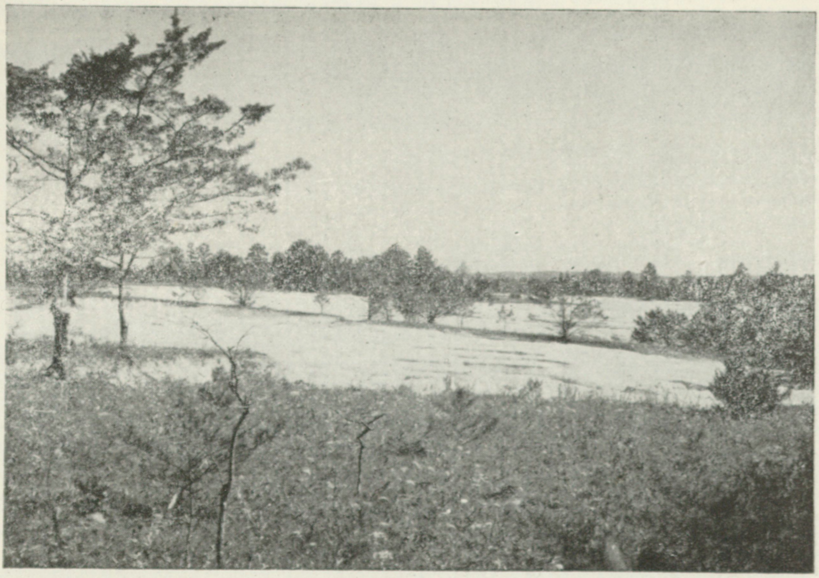

Fig. 4.—Large bald spot exposing the Demopolis member of the Selma chalk. East side of U. S. Highway 43 in sec. 32, T. 18 N., R. 3 E., Marengo County.

The belt of bald spots merges toward the south into more rolling country underlain by chalk of less purity. This rolling prairie forms the foot hills and lower slopes of the High Ridge cuesta of the Chunnennuggee Hills underlain by the Ripley formation.

Cleland (75) in 1920 suggested that the Black Prairie belt may represent a Pleistocene peneplain. He says that although the general appearance of the belt is that of a region of topographic youth because the surface is level and is cut by rivers with steep banks, "the evidences which indicate that the region was peneplained and has been elevated in comparatively recent times are: (a) that it occupies a troughlike depression 200 to 300 feet lower than the bordering lands to the north and south; (b) that, although the soil is a clay and is consequently very favorable for the retention of water, swamps are nevertheless uncommon except in river bottoms, showing that the drainage had been thoroughly established; (c) that the Lafayette, which once covered the Black Belt, has been almost entirely removed from it; (d) that the thick, residual soils of the region were probably formed chiefly after the land was reduced to a peneplain (at the present time they are being rapidly eroded away); (e) that the present youthful appearance of the region is due to a comparatively recent elevation of the peneplain 60 or more feet, which permitted the rivers to sink their beds; (f) that the peneplanation must have taken place during the Pleistocene, as is shown by the fact that the region was reduced to a nearly level surface and that a thick residual soil was formed after the removal of the Lafayette, a formation that was deposited not earlier than later Pliocene and, more probably, during the Pleistocene."

The "Lafayette" referred to by Cleland is, in part, the discontinuous mantle of river-terrace deposits discussed on a later page and, in part, thick residual sand on the hills north of the Black Prairie belt and in the Chunnennuggee Hills to the south. The river-terrace deposits are present now only as remnants, but once covered extensive areas. It does not seem justifiable to call the Black Prairie belt a peneplain, for all areas in the Coastal Plain underlain by evenly eroded rocks like massive chalk or clay are equally flat and are in marked contrast to adjacent regions underlain by sand.

Few writers have called attention to the flat chalk bottoms of most of the creeks in the chalk belts of the Coastal Plain. Stephenson (93) ascribes this phenomenon to alternate wetting and drying of the chalk, which causes large flat pieces to break off. These large pieces accumulate at bends and wide places where there may be some obstruction to the flow of the water during the period of runoff. Most streams that originate in the chalk belt are intermittent, for the chalk is impervious to water and supplies cannot be stored during rainy weather to furnish water for springs in dry seasons. All perennial streams in the belt originate either outside the belt in the sandy formations to the north or south or in the river terrace deposits formerly called Lafayette.

The lack of surface water and springs in the Black Prairie belt causes the inhabitants to depend for water on cisterns dug into the impervious chalk or to drill or bore artesian wells. Artesian wells have been used in this region for many years; Tuomey (12, p. 139) reports wells as far down the dip as Boligee, Greene County, and mentions some as deep as 740 feet. The deepest well before the War Between the States was probably the one bored at Livingston from 1854 to 1857 to a depth of 1,062 feet reported by Smith and Johnson (43, p. 84; 50, pp. 277-278).

Chunnennuggee Hills

In this report I have adopted the name Chunnennuggee Hills to include all parts of the physiographic district to which the name Chunnennuggee Ridge has been applied previously, restricting the name Chunnennuggee Ridge to the actual divide between the drainage of the Alabama River and the drainage of the Conecuh and Pea Rivers. The Chunnennuggee Hills as here defined include 4 distinct cuestas to which the names Sand Fort Cuesta, Enon cuesta, High Ridge cuesta, and Lapine cuesta are applied, and one small area of prairie for which the name Cowikee prairie is proposed. In all but the western part of Alabama the district is bounded on the south by the northern edge of the Southern Red Hills of Harper (67, pp. 97-99). For convenience of discussion the name Troy cuesta is proposed for the northernmost ridge of these hills even though this region is outside the area described in this paper. In the western part of Alabama the Chunnennuggee

Hills slope southward into the Flatwoods, which is underlain by the Sucarnoochee clay, for the Lapine and Troy cuestas are not developed in that area.

Chunnennuggee Ridge.—Chunnennuggee Ridge is a striking physiographic feature that has attracted attention since the first settlers arrived in Alabama. It is a steep northward-facing hill that marks the southern limit of the drainage of the Alabama River and the northern limit of the drainage of the Conecuh and Pea Rivers in Bullock and Montgomery counties. The name originally applied only to the steep hill just north of Union Springs and extending from there toward the east as far as Enon (named in this report the Enon cuesta scarp), the steep northward-facing hill 7 miles south by west of Union Springs trending west into Montgomery County near Pine Level (named in this report the High Ridge cuesta scarp), and the westward-facing hill connecting these two cuesta scarps. This original usage is followed in the present report.

Geographers later extended the name toward the northeast, the west, and the south to include the entire outcrop of the Ripley formation as defined by Langdon (45 and 50). One writer (61) called this feature "The Cuesta" and actually confused it with the Buhrstone cuesta of the Tallahatta formation of the Tertiary.

Sand Fort cuesta.—In the eastern part of Alabama the lower part of the Selma chalk passes laterally into the Blufftown formation, a unit composed of sand and clay with a thick bed of coarse sand and fine gravel at the base. This basal bed is much more resistant to erosion than the soft silts, sands, and clays of the underlying Eutaw formation and forms the Sand Fort cuesta consisting of a steep northward-facing slope about 200 feet high, the cuesta scarp, and a long gentle slope to the south from the crest of the cuesta scarp. This gentle back slope is very nearly a dip slope, for the topography slopes at nearly the same rate as the beds of rock dip.

The cuesta is named for the small settlement of Sand Fort on the crest of the cuesta in the NW¼ sec. 34, T. 16 N., R. 28 E., Russell County.

The scarp of the Sand Fort cuesta is most prominent in Russell County south of Uchee Creek, where it is about 200 feet high. Farther east it is highly dissected by local drainage into the Chattahoochee River. Farther west it becomes lower because the sand

and gravel at the base of the Blufftown formation merge laterally into the much less resistant basal beds of the Selma chalk.

The back slope of the cuesta is not a plane surface but is cut into low, rounded sandy hills composed of higher beds of the Blufftown formation. In the western half of Russell County and in Macon and Bullock Counties the slope merges southward into an eastward extension of the Black Prairie belt caused by an eastward-extending tongue of the lower marly member of the Selma chalk. South of this prairie belt are more sand hills underlain by the Blufftown formation, but these constitute the foot hills and lower slopes of another scarp, the Enon cuesta.

A feature of the Sand Fort cuesta and of other cuestas in the Chunnennuggee Hills is that many streams have their headwaters near the crest of the cuesta and flow down the back slope away from the steep northward-facing scarp. This is especially noticeable in Russell County, where the North Fork of Cowikee Creek, Hatchechubbee Creek, and Ihagee Creek all flow southeast to the Chattahoochee River away from the crest of the cuesta, rather than to the much nearer and lower valley of Uchee Creek north of the cuesta.

Enon cuesta.—The original Chunnennuggee Ridge is the steep northward-facing hill that extends east from Union Springs to Enon with streams to the north flowing into the Alabama River and those to the south flowing into the Conecuh and Pea Rivers. This hill is the scarp of a feature here named the Enon cuesta. The type area between Union Springs and Enon, Bullock County, has a steep northward-facing scarp nearly 200 feet high with a long gentle back slope down the drainage of the Conecuh and Pea Rivers to the south. The cuesta is much less prominent west of Union Springs because coarse sand and fine gravel of the basal Cusseta sand, that give rise to the cuesta, become more marly in that direction and gradually merge into the Demopolis member of the Selma chalk. The position of the cuesta is marked in western Bullock and Montgomery Counties, however, by a line of hills along the western extension of the Enon cuesta.

Near Enon, Bullock County, drainage of the Middle Fork of Cowikee Creek has eaten back into the Cusseta sand with the result that the cuesta scarp bends sharply to the south for about 4 miles before continuing its easterly trend. The Middle and North

Forks of Cowikee Creek cut through the cuesta in the northeastern part of Barbour County, but the scarp is present between the streams as a series of high hills. The scarp is well developed northeast of the North Fork of Cowikee Creek, where it is a high northwestward facing hill at Glenville, Russell County. Hatchechubbee Creek cuts through the cuesta to reach the Chattahoochee River, but the cuesta is present northeast of the creek as a series of high hills that slope southeast toward the Chattahoochee valley.

The gentle back slope of the cuesta gives rise to a wide outcrop of the Cusseta sand in eastern Barbour and Russell Counties, for the basal beds of the Cusseta dip southeast at nearly the same rate as the topography slopes toward the Chattahoochee River. In the western part of Barbour County and the southeastern corner of Bullock County the back slope has been so deeply incised by drainage of the South Fork of Cowikee Creek that the upper part of the Blufftown formation and the underlying tongue of marl of the Selma chalk are exposed. Without this dissection the slope of the cuesta would be continuous from the crest of Spring Hill at the north to the northward-facing scarp of the Lapine cuesta (the High Ridge cuesta is missing in this region). The marl exposed by this dissection forms a narrow belt of prairie which is described below as the Cowikee prairie.

The back slope of the Enon cuesta is almost perfectly developed farther west in Bullock County in the area for 10 miles south of Peachburg. There the general slope of the topography is toward the south parallel to the drainage of the headwaters of the Pea River. The gently rolling hills are covered by a thick mantle of leached white sand, but deep road cuts reveal dark blue-gray unfossiliferous fine sand of the Cusseta.

West of Union Springs the Enon cuesta is not so well developed, for drainage of Oakfuskee Creek has cut back through the cuesta as far as the High Ridge cuesta to the south. The back slope in this region is not so noticeable a feature as it is farther east, but comprises rolling hills of sand and clay, that do not appear to slope to the south.

In the western part of Bullock County the Enon cuesta appears to die out in a line of hills of sand that trend eastward across Montgomery County coincident with the westward-extending tongue of the Cusseta sand between the two eastward-extending tongues of the Demopolis member of the Selma chalk.

An interesting feature of the topography at the top of the Enon cuesta near Union Springs is the valley of the Conecuh River which flows due west parallel to the cuesta scarp and only about a mile south of the top of this steep northward-facing slope. In places the stream is less than a quarter of a mile from the divide north of which the drainage flows to the Alabama River. At the east side of Union Springs the river has been artificially diverted over the rim into Town Creek forming a waterfall known as Conecuh Falls (fig. 5), and the power developed by this artificial waterfall was used for many years to run a grist mill. The valley of the Conecuh River below the diversion canal has now silted up and only flood waters continue down the old valley. All other drainage is into Town Creek and thence to the Alabama River. The present head of the Conecuh River is a group of springs at the southeast edge of Union Springs.

Fig. 5.—Conecuh Falls at east side of Union Springs, Bullock County. The Conecuh River has been artificially diverted over the edge of the Enon cuesta scarp to run a grist mill. The clayey sand exposed here is near the top of the Blufftown formation.

Cowikee prairie.—Deep incision of the South Fork of Cowikee Creek into the back slope of the Enon cuesta in Barbour County has exposed a small area of the lower marly member of the Selma chalk, which has weathered to a small strip of prairie about 10 miles long and 3 miles wide. This patch of prairie in the "blue marl land" of the formations formerly included in the Ripley formation has long been a puzzle to geologists. Thornton (21, pp. 241-242) describes this area as follows:

> At Browder's bridge, one mile North of Fort Browder, the Cowikee has cut its way through two beds of marl. The upper stratum is compact and broken into joints. When moist it has a bluish color, but when dry it is white, resembling rotten limestone, but containing a much smaller quantity of lime. The lower stratum is of a coarse sandy texture with scattering grains of greensand. The only fossils in this locality are *ostrea plumosa, anomia argentea* [*Anomia argentaria*] *exogyra costata* [*Exogyra ponderosa*], sharks' teeth of various kinds and some casts.
>
> These beds may be seen on Bear and Dry creeks, and constitute in many places the sub-soil of a strip of country from three to five miles in width, lying in the fork of south and middle Cowikee.
>
> The presence of the marl is shown by white lime pebbles and crystals of calc-spar mixed with the soil. Cracks in the rock are filled with the latter mineral. Unlike most lime land, this has a growth of long-leaf pine. Here and there throughout this strip are spots of land, from an acre to two acres in extent, known as hog-wallow land.

Smith, Johnson, and Langdon (50, pp. 563-564) describe this part of their Ripley group as follows: "This makes a soil somewhat like that of the Rotten Limestone, except that it is generally of a reddish color."

The Cowikee prairie is distinct from the bordering sandy hills not only in the soil, which is classified as Houston clay and Susquehanna clay depending on the presence of lime, but also in the gentler topography. The prairie slopes nearly parallel to the dip of the rocks from the south side of Spring Hill nearly to Comer.

High Ridge cuesta.—In the southeastern part of Bullock County a segment of Chunnennuggee Ridge extends west by north from Jenkins crossroads (near southeast corner sec. 7, T. 12 N., R. 23 E.) to Pine Level in Montgomery County. This part of the ridge is known locally as High Ridge, and the cuesta of which this hill is the scarp is here called the High Ridge cuesta after the hill and a small settlement of the same name on the crest in sec. 36,

T. 13 N., R. 21 E., Bullock County. In this type area the High Ridge cuesta scarp rises from 120 to 150 feet above the lower land to the north. The back slope is very nearly a dip slope, for the slope is about 33 feet to the mile in T. 12 N., R. 22 E., and the dip is about 30 feet to the mile. The cuesta scarp is drained by tributaries of Oakfuskee Creek, which flows into the Tallapoosa River. The back slope is drained by tributaries of the Conecuh River.

East of Jenkins Crossroads the scarp of the High Ridge cuesta is not so prominent as farther west, for the lower land to the north is drained by the Conecuh River rather than by streams flowing to the Alabama River. The gravel-capped hills at the top of the scarp, however, are noticeable in the area, and the cuesta appears to continue across the county. In the western part of Barbour County the Ripley formation is apparently overlapped by the Providence sand, and the High Ridge cuesta merges into the scarp to the south, the Lapine cuesta, caused by the resistant beds of the Providence sand. Farther east in central Barbour County the High Ridge cuesta is again a prominent feature of the topography and extends northeast to the valley of Cowikee Creek where it is covered by the flat terraces of the Chattahoochee River.

To the west of the type area the cuesta is the most prominent feature of the landscape as it rises a hundred feet or more above the low, flat Black Prairie belt to the north. It is readily traceable to the Mississippi State line except in the terraced valleys of the Alabama and Tombigbee Rivers, where all surface irregularities have been concealed by river terraces of sand and gravel.

The High Ridge cuesta is succeeded to the south by the scarp of the Lapine cuesta from the Chattahoochee River region westward to the western part of Lowndes County, where the Providence sand merges laterally into the marly and chalky Prairie Bluff. West of Lowndes County the Prairie Bluff chalk is present on the southern part of the back slope of the High Ridge cuesta and the topographic feature to the south is the scarp of the Troy cuesta of the Southern Red Hills physiographic district. This scarp extends west into Marengo County, becoming lower in that direction until it disappears near the Tombigbee River. In Sumter County the High Ridge cuesta is bounded on the south by the Flatwoods, a physiographic district characterized by gentle topo-

graphy like that of the Black Prairie, but heavily covered by forest. The formation underlying the Flatwoods is the Sucarnoochee clay. Small local accumulations of sand at the base of the Sucarnoochee clay cause low hills that might be considered recurrences of the Troy cuesta.

The correlative of the High Ridge cuesta in Mississippi is the physiographic district to which the name Pontotoc Hills is applied.

Lapine cuesta.—The Lapine cuesta is a part of the Chunnennuggee Hills physiographic division, but is south of the area of outcrop of the rocks described in this report. It is caused by the resistant sand and gravel of the Providence sand, which merges laterally into the Prairie Bluff chalk. The Providence sand and the Prairie Bluff chalk intertongue over a wide area between Perote, Bullock County, and Fort Deposit, Lowndes County. Only a few feet of marl of the Prairie Bluff chalk underlies the Providence at Perote and successively higher parts of the Providence merge into the chalk toward the west. As this happens the boundary between the Providence and the Prairie Bluff moves south away from the boundary between the Ripley and the Prairie Bluff chalk. The scarp of the Lapine cuesta coincides with the lower part of the Providence sand, so toward the west this topographic feature also passes gradually south away from the outcrop of the Ripley formation. The Lapine cuesta is from 150 to 200 feet high in Barbour County, but is lower farther west. It finally dies out in the western part of Lowndes County between Fort Deposit and Braggs.

The type area may be considered the high northward-facing hill near Lapine on the county line between Montgomery and Pike Counties.

Southern Red Hills

Troy cuesta.—The Southern Red Hills are underlain by Tertiary rocks and are south of the region covered in this report. The northernmost topographic feature of the hills in the eastern part of Alabama, however, marks the southern limit of the Chunnennuggee Hills and will be described here. Troy, Pike County, is built on an upland plain that slopes gently toward the south. Two

miles north of town this plain is terminated abruptly by a steep drop of more than 100 feet to a lower plain that rises gently to the north. This sharp declivity is the scarp of the Troy cuesta and can be traced coincident with the northern edge of the Clayton formation from the Chattahoochee River on the east to Marengo County on the west, where the scarp disappears as the Clayton formation intertongues and merges into the Sucarnoochee clay which underlies the Flatwoods physiographic division.

Major streams

Three major rivers cross the region described in this paper —the Tombigbee (and its tributary the Black Warrior), the Alabama, and the Chattahoochee. The Alabama and the Chattahoochee rise in the Piedmont physiographic province, and the Tombigbee and Black Warrior in the Appalachian Plateau province and the inner part of the Coastal Plain.

All these rivers except the Chattahoochee have a feature in common: the distribution of terrace deposits mainly on the left banks and the predominance of high bluffs on the right banks indicate that the streams have migrated to the right regardless of dip or relative hardness of the rocks. This is especially well shown by the Tombigbee River in Mississippi and the Alabama River in Lowndes and Dallas Counties in Alabama. The Tombigbee flows from Amory south and southeast to the Alabama State line on the Tombigbee sand member of the Eutaw formation near the boundary with the Selma chalk. East (left) of the river gravel-covered terraces rise in steps to the outcrop of the gravel-free Eutaw deposits high in the upland. There is no gravel west (right) of the river at comparable altitudes. This shows conclusively that the river has migrated west from each flood plain that it once used to a lower level where it cut a new flood plain and covered it in turn with gravel. As this migration has been down the dip it has long been assumed that the river merely cut its flood plain back against the resistant Selma chalk and gradually migrated down the dip as it wore away the chalk.

The Alabama River flows on the Eutaw formation nearly due west from Montgomery to Selma cutting against the bluffs of Selma chalk to the south. The terrace deposits of the Alabama, however, are predominantly on the left bank high on hills under-

lain by the Selma chalk. This indicates that the river once flowed far south of its present position and has gradually migrated *up* the dip to its present position.

This same migration to the right is true of the Black Warrior River valley, but is not so strikingly developed. The phenomenon has not been explained by geographers working in the area, but it seems likely that the answer will be found in the tendency of moving bodies to migrate to the right in the northern hemisphere, regardless of direction of flow, because of rotation of the earth. It is certainly not true that the terraces on the Tombigbee and Alabama Rivers represent flood plains that once were as wide as the distance from the old stream-cut bank to the present channel of the river. I have not yet been able to study these terrace deposits in detail, but I venture the assertion that on careful reconstruction of these old flood plains it will be found that they approximate the present flood plains in width.

Lower terraces near the present flood plains of the rivers have long been recognized, but the higher terraces many miles away have been described by the earlier workers as remnants of the "Lafayette" formation. If by Lafayette they meant the deposits now known as the Citronelle formation in the southern part of Alabama the position is untenable because the gravels are separated from the main body of the Citronelle by the high cuestas of the Coastal Plain including such great ridges as the Buhrstone cuesta, which is much higher than any of the Cretaceous cuestas described in the preceding pages of this report.

The study of the terrace deposits of the Alabama river and reconstruction of the old flood plains of the river, which were successively abandoned for lower plains, constitute a most interesting problem. Small gravel-covered areas on the right of the present flood plain of the river show that the migration toward the right has not been constant but merely a general trend. Recent maps of the soils of Autauga, Dallas, Lowndes, and Montgomery Counties, which show numerous abandoned channels on the terraces, will aid in unravelling the complex history of the river.

The Chattahoochee River is bordered by terrace deposits, mostly on the right bank in contrast to the others which have the larger deposits on the left bank. Throughout its course through the Upper Cretaceous rocks the river flows in a relatively narrow valley with only narrow terraces on each side. The streams flow-

ing in from the west are all short, rather swift, and rapidly eroding. Stephenson (79, p. 892) has suggested that the Chattahoochee River region is a broad anticline into which the Chattahoochee River has cut its valley. I have not studied the geology of the lower course of the river, but in the area of outcrop of the Upper Cretaceous series the main structural feature seems to be the Comer salient, which from my rather superficial study appears to be the place of a sharp change in strike of the rocks rather than a place of structural uplift. More careful future study will probably show whether the deep trenching of the Chattahoochee River is due to structural movement or some other cause. An alternative theory is that the water in the Chattahoochee River has a much shorter course to the Gulf than that in the Alabama River or even in the Pea and Conecuh Rivers, and thus, in effect, has a lower baselevel in eastern Alabama.

STRUCTURE

In general the deposits of Selma and Ripley age dip gently away from the Appalachian upland to the north and northeast. The strike of the formations is approximately southeast in the western part of the State, but swings around in the central part to nearly due east. In the western part of Barbour County it changes sharply from a few degrees south of due east to northeast. This change in strike is so sharp that I have called it the Comer salient from the village of Comer in Barbour County. There has been no apparent uplift to produce an anticline or dome in this area, but the change in strike is so sharp that structure contours drawn on key horizons resemble those drawn on a plunging anticline. Some evidence of faulting in the area (dips as high as 10°) has been observed on the Mount Andrew-Midway road. The Ripley formation east of Mount Andrew is apparently overlapped by the Providence sand, or is cut out by a fault. These complexities of structure should be studied in greater detail than has been possible in the time available for the present field work.

The general monoclinal dip of the Cretaceous formations is interrupted in two areas by complex faulting. The larger area is a long, narrow strip in Sumter and Marengo Counties in which the Prairie Bluff chalk, the Ripley formation, and the Demopolis member of the Selma chalk are involved. This area is left blank on the geologic map (pl. 1) because the fault blocks are so narrow that they cannot be shown. In detailed work in the Epes quadrangle all these faults proved to be reverse (figs. 11 and 12). The faults strike about parallel to the strike of the formations and dip about 45° southwest and northeast, the displacement ranges from a few inches to about a hundred feet, and the long narrow fault blocks, less than 500 feet wide, are continuous for at least two miles. No attempt has yet been made to trace them for longer distances. The belt of intense faulting averages about a mile and a half in width, and reverse faults have been found for a distance of 28 miles along the strike from the Tombigbee River to Emelle. None of the faults has been traced individually throughout this distance, but the trends indicate that all belong to one system of faults.

The other area of faulting is in the hills south and southeast of Wetumpka, Elmore County. Only half a day was spent studying this area and the following statements are little more than

guesses. Bald Knob east of town is about 550 feet high and is composed almost entirely of metamorphic rock. On the south slopes, however, highly faulted Tuscaloosa beds and at the foot of the hill marl of the lower member of the Selma chalk crop out. Two large faults, therefore, are present, one between the crystalline metamorphic rocks and the Tuscaloosa formation, and the other between the Tuscaloosa formation and the Selma chalk. The fault between the Tuscaloosa and Selma is noteworthy for most of the Tuscaloosa formation and all the Eutaw formation are cut out—a thickness of at least 300 feet. Farther south other faults account for the alternation of blocks of Eutaw and Selma for about 3 miles. Still farther south, on the Wetumpka-Montgomery highway, apparently undisturbed Tuscaloosa is exposed from the bottoms to the tops of deep cuts. One of the faults between the Eutaw and the Selma formations was seen in a cut on a local road in the SW¼ SW¼ sec. 29, T. 18 N., R. 19 E. The fault is normal and trends N. 60° W., with Eutaw to the north and Selma to the south. The fault plane dips 80° S. 30° W. Exposures are few in these hills and critical areas are covered by thick mantles of terrace gravel of the Coosa and Tallapoosa Rivers. The fault pattern shown on the geologic map (pl. 1) was drawn after studying a soil map of Elmore County now in preparation by Mr. L. G. Brackeen of the Alabama Department of Agriculture, who very kindly gave permission to use his results.

Small normal faults affecting Upper Cretaceous deposits have been seen at several places near the Chattahoochee River, but little could be deduced from the cursory examination given them. Future work is undoubtedly going to show that faults are exceedingly common in the belt of outcrop of Upper Cretaceous rocks in Alabama.

No signs of folds of any consequence other than the suggested salient near Comer have been seen, but it must be remembered that this work has been little more than a hasty reconnaissance.

STRATIGRAPHY

SELMA CHALK

Name.—The name Selma was proposed in 1894 by Smith, Johnson, and Langdon (50, p. 276) as a co-name with the somewhat misleading descriptive term "Rotten limestone", which had been introduced by Winchell (16, pp. 91-92) for the Cretaceous chalk of Alabama. The type locality of the Selma chalk is in the bluff of the Alabama River at Selma, one of the localities mentioned by Winchell, and is near the base of the lower marly member of the formation.

The upper hundred feet or less of the Selma chalk of Smith, Johnson and Langdon has recently (94, pp. 806-808) been differentiated from the Selma under the formation name Prairie Bluff chalk, which includes the Prairie Bluff tongue of the Selma chalk of Stephenson (71, p. 250).

Chalky sand that underlies the Prairie Bluff chalk in Sumter County and that merges eastward into the Ripley formation has previously been called a part of the Selma chalk. In this report, however, it is treated as a chalky facies of the Ripley formation, restricting the name Selma to the purer underlying chalk. Thus the Selma is now restricted to marl and chalk that intervene between the Eutaw formation below and the Ripley formation above.

For convenience of discussion the Selma has been divided into three distinct lithologic members: an unnamed lower member that includes the typical chalky marl exposed at Selma, a thin member of alternating limestone and marl designated the Arcola limestone member, and an upper member of purer chalk designated the Demopolis member. These are discussed in detail below.

Lower marly member of the Selma chalk

Areal extent.—The lower marly member of the Selma chalk crops out in a belt having an average width of eight miles from the Mississippi State line in Pickens County southeastward through Sumter, Greene, Hale, Perry, Dallas, Lowndes, and Montgomery Counties, with outliers in Autauga and Elmore Counties. In Macon and Bullock Counties the belt narrows progressively

eastward because the upper and lower parts of the member merge laterally into westward-extending tongues of the Blufftown formation. The eastward-extending tongue of this marly member of the Selma merges into sandy clay of the Blufftown formation in the southwestern part of Russell County. Deep incision by the headwaters of the South Fork of Cowikee Creek in the southeastern corner of Bullock County and the northwestern part of Barbour County exposes a large area of the member in a region that would normally be covered by the Cusseta sand. This inlier is roughly 10 miles long and 3 miles wide.

Lithologic character.—The lower member of the Selma chalk consists of fairly uniform more or less thin-bedded chalky marl or marly chalk, generally dark-gray to dark blue-gray where fresh and white to cream-colored where weathered, except the basal 3 to 6 feet, which consists of compact calcareous sandstone containing scattered quartz pebbles, phosphatic pellets, and phosphatic internal molds of fossil shells. Much more time has been spent on the contact of the Selma with the underlying Eutaw formation than on higher parts of the formation, so the following account includes many more detailed descriptions of the basal beds than their thickness justifies.

Smith made a careful study of the basal beds of the Selma chalk and the uppermost beds of the underlying Eutaw formation because he discovered that they contain considerable phosphate. He first called attention to the phosphate in 1884 (39, 40, 41, and 42) and later published Bulletin 2 of the Alabama Geological Survey (49, reprinted in 50, pp. 457-470) in which he described in more or less detail phosphatic exposures from Pickens County on the west to Elmore County on the east. Numerous analyses of the phosphatic molds, nodules, and matrix are included.

The westernmost point in Alabama at which I have seen the contact of the Selma and Eutaw formations is on the road to the St. Louis-San Francisco Railway station at Pickensville, Pickens County. On the slope down to the Tombigbee River Valley 20 feet of highly glauconitic fine sand of the Tombigbee sand member of the Eutaw formation is overlain disconformably by about 25 feet of sandy glauconitic Selma chalk containing in the basal part abundant phosphatic concretions and phosphatic internal molds of fossils.

The basal bed of the Selma is well exposed on a local road in the NE¼ NW¼ sec. 6, T. 22 S., R. 16 W., Pickens County, about

8 feet above the nearby track of the St. Louis-San Francisco Railway at an altitude of about 168 feet. This is the southwestern end of a large outlier of the Selma that forms a notable area of prairie soil on Alabama Highway 40 in the SW¼ SW¼ sec. 29, T. 21 S., R. 16 W., where more than 30 feet of chalky clay is exposed near the crest of a westward-facing slope. At this exposure a rudistid was found.

The contact of the Eutaw and Selma is exposed in Greene County on this same highway just south of the Sipsey River about 40 feet above the flood plain. The contact is readily traceable toward the southeast by the sharp change in soils, even at places where road cuts are not deep enough to show the details of the contact in the unweathered state. The contact is exposed at several places near Eutaw, but none of these is as instructive as the exposure at Choctaw Bluff (fig. 6) on the Black Warrior River, 5 miles south by east of Eutaw in the NW¼ NW¼ sec. 26, T. 21 N., R. 2 E.

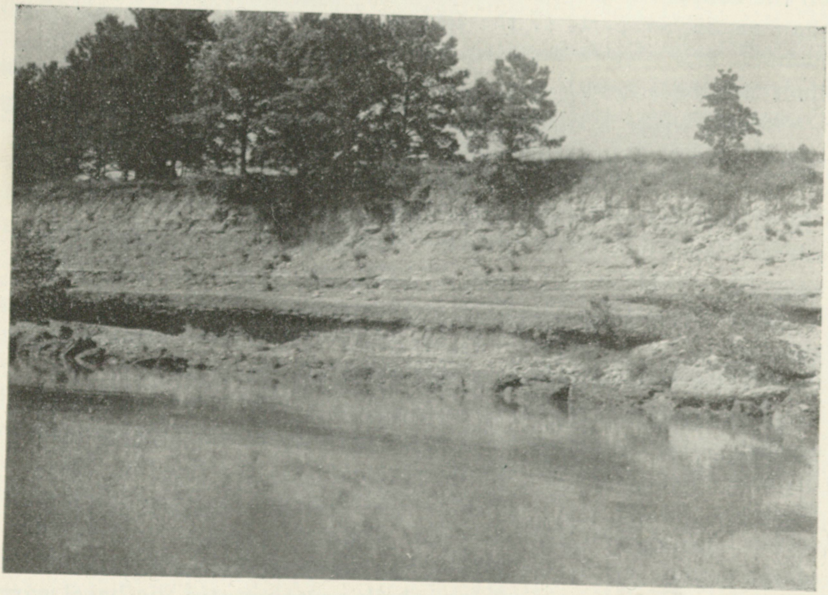

Fig. 6.—Choctaw Bluff on the Black Warrior River, Greene County. The indurated layer that projects from the face of the bluff near the base is compact sandstone considered the basal conglomerate of the Selma chalk. It is overlain by thin-bedded chalky marl. The less compact sand below the sandstone layer is the Tombigbee sand member of the Eutaw formation.

Section at Choctaw Bluff, Black Warrior River, Greene County

	Feet
River terrace deposit and weathered Selma chalk:	
Red and gray clay containing a few quartz pebbles	13.0
Selma chalk:	
Thin-bedded gray chalky marl	25.0
Hard calcareous sandstone containing phosphatic molds and a few quartz pebbles; highly irregular base	4.5
Disconformity.	
Eutaw formation (Tombigbee sand member):	
Sparingly glauconitic fine sand containing many pieces of partly lignitized wood perforated by *Teredo* tubes	11.0
	53.5

This exposure has been mentioned frequently in the geologic literature of the region. It was first formally described by Toumey (12, pp. 120-122) and later by Winchell (14, pp. 150-153) who visited the place before the dams on the Black Warrior River were built and thus were able to see beds that are now under water. At the bottom of Winchell's section is 5 feet of "dark-colored shale, sandy at top, and constituting the bed of the river." Above this he reports a 1-foot bed of green sand. I have never seen either of these two beds exposed.

Smith and Johnson (43, p. 90; 50, p. 295) described the section at Choctaw Bluff and noted the presence of phosphate in their bed 4 "Indurated ledge of glauconitic sand and small oysters, slightly effervescent, phosphatic," and in the bottom 6 or 8 feet. I have placed the contact of the Selma chalk and the underlying Eutaw formation about 6 feet lower than Smith and Johnson—at the base rather than the top of their bed 2.

Willard Payne of the California Company very kindly showed me a number of outliers of the Selma chalk between Sawyerville and Wedgeworth in Hale County. At one of these in the ditch at the side of Alabama Highway 41 at the north edge of sec. 26, T. 21 N., R. 3 E., the contact with the underlying Tombigbee sand member of the Eutaw formation is exposed.

Abundant phosphatic molds of mollusks are contained in the basal beds of the Selma in a road cut at the crest of the northward-facing slope of Hines Creek at the northeast corner of sec. 18, T. 20 N., R. 4 E., Hale County.

Section on northward-facing slope of Hines Creek, 2¾ miles south-southeast of Sawyerville, Hale County

	Feet
Selma chalk:	
Very glauconitic calcareous sand merging downward into glauconitic calcareous sandstone containing *Exogyra ponderosa*, *Gryphaea wratheri*, and abundant phosphatic molds of fossils	6
Disconformity (very irregular surface).	
Eutaw formation (Tombigbee sand member):	
Massive tan glauconitic fine sand containing *Halymenites major;* a few thin clay layers near base	34
	40

The contact is readily traceable east-southeastward through Hale, Perry, and Dallas Counties to the vicinity of Selma, where an instructive section is exposed in the bank of Valley Creek just north of U. S. Highway 80, a mile west of Selma in the SW¼ SE¼ sec. 23, T. 17 N., R. 10 E.

Section in bank of Valley Creek a mile west of Selma, Dallas County

	Feet
Terrace deposit of Alabama River:	
Orange and yellow fine sand containing a 3-inch bed of well-rounded quartz pebbles at base	10.0
Disconformity.	
Selma chalk:	
Compact finely sandy chalk and chalky sand containing phosphatic molds of fossils and some small pebbles of calcareous glauconitic sand reworked into the base; a small piece of lignite observed 2 inches above the base	1.0
Disconformity (contact irregular).	
Eutaw formation (Tombigbee sand member):	
Dark-gray sandy clay stained by limonite; resembles an old soil	.5
Tightly cemented chalky, glauconitic sand; very ferruginous at base	3.0
Massive highly glauconitic, micaceous fine sand containing slightly indurated sand-filled borings	7.0
Tightly cemented, very hard sandstone containing large numbers of oysters; thickness varies from 4 inches to	1.0
Gray glauconitic, micaceous fine sand containing prints of fossils and, at one place, oyster shells; about 3 feet above base is a bed containing large numbers of echinoids like those at the Lower Falls of Catoma Creek near Montgomery, Montgomery County; to water level of creek	8.0
	30.5

Between Selma and Montgomery the bluffs on the Alabama River reveal the contact at many places. Especially good exposures are afforded at Batte Smith Bluff, Cunningham's Bluff, and House Bluff; the latter is described by Smith, Johnson and Langdon (50, pp. 297-298). At these bluffs the basal beds of the Selma consist of 2 or more feet of very tough sandy marl containing abundant phosphatic nodules and phosphatic molds of fossils.

The clay bed that resembles an old soil in the section at Valley Creek near Selma was seen in the bluff on the Alabama River just below the mouth of Pintlalla Creek at the northeast corner of Lowndes County in the NW¼ NW¼ sec. 30, T. 16 N., R. 16 E.

Section in bluff and gully just below Pintlalla Creek on Alabama River

	Feet
Selma chalk:	
Cream-colored finely sandy chalk containing ammonites and phosphatic molds of other fossils	15.0
Disconformity.	
Eutaw formation (Tombigbee sand member):	
Dark-brown plastic clay resembling an old soil; contains broken blocks of limestone; 6 inches to	1.0
Chalky sand	5.0
Bed composed almost entirely of the shells of *Ostrea battensis*	0.7
Blue-gray (weathering brown) glauconitic fine sand containing 1-foot beds of laminated blue clay	30.0
Very hard limestone containing oyster shells, *Trigonia* sp., and other fossils	0.7
Soft yellow medium-grained sand containing abundant impressions of fossils	1.8
Hard fossiliferous limestone	0.3
Soft light-yellow slightly glauconitic sand	0.5
Hard fossiliferous slightly sandy limestone; to water's edge	2.0
	57.0

The easternmost point at which Selma chalk has been found resting on the Eutaw formation is about a mile north by east of Chesson in a road cut on the northward-facing slope of Old Town Creek Valley in the SW¼ sec. 1, T. 15 N., R. 21 E., Macon County.

Section in road cut a mile north by east of Chesson, Macon County

	Feet
Selma chalk:	
Residual clay containing phosphatic molds	20.0
Eutaw formation (Tombigbee sand member):	
Chalky fine sand	11.0
Hard sandy limestone	0.5
Soft chalky sand	1.0
Hard calcareous sandstone	1.0
Very finely glauconitic sand	3.0
Hard calcareous sandstone	0.5
Finely glauconitic sand	0.5
Hard calcareous sandstone	1.0
Very finely glauconitic sand	5.0
	43.5

East of Hardaway, Macon County, the Selma chalk rests conformably on a westward-extending tongue of the Blufftown formation. Descriptions of the contact near Hurtsboro, Russell County, are included in the details of the lithologic character of the Blufftown formation.

The material composing the inlier of Selma chalk in the southeastern part of Bullock County and the northwestern part of Barbour County is predominantly very sandy chalky clay. Smith, Johnson, and Langdon (50, pp. 563-564) describe this material as follows:

> In the northern part of the county [Barbour], in the drainage area of two upper forks of Cowikee Creek, there is a good deal of what is known as 'hog wallow' prairie, which is based upon this tough clay. This makes a soil somewhat like that of the Rotten Limestone, except that it is generally of a reddish color. In the immediate vicinity of the creeks and their tributaries the clay is tempered with sands, and the resulting soils are correspondingly easier of cultivation while at the same time more than ordinarily fertile.

Thornton (21, pp. 241-242) had earlier described this expanse of prairie, but these earlier workers did not recognize that the marl is at essentially the same stratigraphic position as that between Tuskegee and Union Springs.

I have examined few exposures of the Selma between its base and the Arcola limestone member, but at those few places visited it consists of fairly uniform more or less stratified very clayey chalk or marl, at some places containing considerable sand.

Thickness.—In the western part of Alabama the lower marly member of the Selma chalk is about 265 feet thick. The well of Mr. Lewis C. Chapman in sec. 3, T. 16 N., R. 18 E., Noxubee County, Mississippi, penetrated 180 feet of Selma chalk before entering sand of the Eutaw formation. The top of Mr. Chapman's well is about 80 feet stratigraphically below the base of the Arcola limestone member. The log of this well is published in Bulletin 40 of the Mississippi Geological Survey.

Smith and Johnson (43, p. 84; 50, pp. 277-278) give the log of a well completed in 1857 at Livingston, Sumter County, in which the Arcola limestone member is described as "hard, gritty, bluish colored rock, so hard that it had to be drilled, 6 or 8 inches". The base of this rock is said to be at 690 feet, and the base of the 6-foot bed of hard sandstone that probably represents the base of the Selma chalk is reported at 956 feet. The thickness of the lower marly member in this well is, therefore, about 266 feet.

Few records of wells farther east give an approximation of the thickness of the lower marly member of the Selma, but there are several indications that the member may be much thicker in the east-central part of the State. In Montgomery County the Montgomery Oil Company's Snowdoun well is reported by Semmes (81, p. 306) to have penetrated 350 feet of shale and gumbo that he assigns to the Selma before entering the Eutaw formation. As Snowdoun is about 4 miles north of the outcrop of the Arcola limestone member of the Selma, the thickness of the lower marly member in this region may be more than 450 feet. This figure is somewhat greater than the estimate of 380 feet for the thickness of the equivalent Blufftown formation given elsewhere in this report.

Stratigraphic relations.—The Selma chalk rests disconformably on the Tombigbee sand member of the Eutaw formation from the Mississippi State line in Pickens County eastward to the western part of Macon County near Hardaway, where the lower part of the Selma merges laterally into the lower part of the Blufftown formation. To the east of Hardaway the Selma rests conformably on the westward-extending tongue of the Blufftown. The lower marly member of the Selma is overlain conformably by the Arcola limestone member of the Selma from the Mississippi State line to the west-central part of Bullock County. Near Union

Springs both the upper part of the lower marly member and the Arcola limestone member merge laterally into another tongue of the Blufftown formation that extends westward from the main body of the formation. The lower marly member of the Selma continues eastward between these two tongues of the Blufftown, becoming gradually thinner in that direction because of lateral merging of parts of the marl into sand of the Blufftown, to the vicinity of Rutherford, Russell County, where the easternmost part of the marl tongue merges imperceptibly into clay of the Blufftown formation.

The disconformity between the Tombigbee sand member of the Eutaw formation and the lower marly member of the Selma chalk is distinct at all fresh outcrops, and is characterized by a basal conglomerate in the Selma of sand reworked from the underlying Eutaw, of phosphatic nodules and molds of fossils, and at some places of numerous small quartz pebbles. The time interval recorded by this disconformity, however, is probably very short, for similar fossils are found in the Tombigbee sand and in the basal Selma chalk.

This member includes most of the lower half of the *Exogyra ponderosa* zone, the lower of the two great faunal zones in the Upper Cretaceous of the Coastal Plain.

In Lee County, Mississippi, the lower marly member of the Selma and the Arcola limestone member together constitute the main body of the Mooreville tongue of the Selma chalk that extends northward beneath the Tupelo tongue of the Coffee sand. North of Lee County these parts of the Selma are represented by the lower part of the Coffee sand, which extends northward about half way across Tennessee.

Correlations with other states are copied from a correlation chart (100) which is to be published by the Geological Society of America. In Arkansas the member appears to be represented by the upper part of the Tokio formation, the Brownstown marl, the Ozan formation, and possibly the lower part of the Annona chalk. Still farther west in Texas the unit is equivalent to the upper part of the Austin chalk and the lower part of the Taylor marl.

In eastern Alabama and Georgia the Selma chalk up to and including the Arcola limestone member is represented by its exact

time equivalent the Blufftown formation. The Blufftown formation is overlapped by the Cusseta sand in the west-central part of Georgia according to Cooke (97), but beds of equivalent age are apparently present in the lower part of the Black Creek formation in the Carolinas.

In the New Jersey section the lower marly member of the Selma is probably equivalent to the lower part of the Matawan group.

According to studies of L. W. Stephenson the unit is of upper Santonian and lower Campanian age in the European section.

Physiographic expression.—The lower marly member of the Selma gives rise to the gently rolling prairie land that constitutes the typical black prairie of Alabama. Throughout most of its belt of outcrop the formation is covered by a thick mantle of black soil to which the name Houston clay is applied by soil scientists. Smaller areas of the prairie soils called Sumter and Vaiden constitute most of the rest of the outcrop area of the lower marly member of the Selma.

Away from the major streams the topography is low but gently rolling in slopes that have in places as little a declivity as 1 foot in a hundred (fig. 2). On the upland the steepest slopes at few places exceed 10 percent. In this region of such gentle topography it is exceptional to find in a square mile greater relief than 80 feet.

This part of Alabama is one of the most beautiful in the State, for the deep black soil is a typical grassland and in the warmer months of the year the gently rolling upland is covered by a thick carpet of fine grass interrupted at the proper seasons by a nearly continuous mantle of primroses, a flower so widely scattered in the region that it is considered a weed by many of the planters.

For generations this part of Alabama has been considered the prime agricultural land of the State and the land is held in large plantations many of which have been in the same families for more than a hundred years. On the higher hills the old plantation houses are prominent features of the landscape and many are considered show places of the State.

Arcola limestone member of the Selma chalk

Name.—This thin limestone unit in the Selma chalk was observed as early as 1833 when Withers (3) said:

"There is one variety of it [chalk], however, which is found on some of the hills below this place in detached, porous, honeycomb fragments which makes lime strong enough for common use."

Tuomey (12, pp. 122-123), Thornton (21, pp. 241-242), Smith and Johnson (43, p. 85; 50, pp. 279-280), and others have described this rock as "bored limestone" and have discussed part of its areal extent, but it was not until 1938 that it was given the formal geologic name of Arcola limestone member of the Selma chalk by Stephenson and Monroe (96, pp. 1655-1657). The type locality is at the bluff on the Warrior River at old Arcola Landing in the NE¼ sec. 4, T. 18 N., R. 3 E., Hale County, about 5 miles (air line) northeast of Demopolis.

Areal extent.—The Arcola limestone member has been traced from the vicinity of Mooreville, Lee County, Mississippi, south and southeast into Pickens County, Alabama, where it forms a prominent northeastward-facing scarp near Dancy. From Pickens County the limestone trends southeastward and eastward through Sumter, Greene, Hale, Perry, Dallas, Lowndes, and Montgomery Counties. The easternmost typical exposure of the limestone that I have seen is near Downing in Montgomery County, but in the western part of Bullock County beds of calcareous sandstone occupy the same stratigraphic position as the limestone farther west, and for convenience have been included in the member. Near Union Springs, Bullock County, the member merges laterally into the uppermost part of the Blufftown formation. Beds of very hard sandy limestone in the upper part of the Blufftown formation appear to be the eastward continuation of the Arcola limestone member of the Selma, but this relationship has not as yet been certainly established.

Lithologic character.—The Arcola limestone member consists of one or more beds of nearly pure, hard limestone interbedded with soft marl. In Mississippi the member consists of only one bed of limestone overlain by marl of variable thickness, but at all outcrops of the member in Alabama thus far examined the member

comprises 2 or more beds of limestone separated by thin beds of marl and overlain by a thin bed of marl. The limestone is perforated by numerous holes or borings that are filled with soft marl. On weathering this marl is washed out leaving highly perforated fragments. It is this characteristic that led observers to call the limestone the "bored rock". (See fig. 7).

Fig. 7.—The Arcola limestone member of the Selma chalk in a cut on the Scotts Station road, 5.2 miles north of Uniontown, Perry County. Characteristic "bored rock" is exposed at the top of the bank (dark spot on block of white limestone). The hammer is resting on a second, less weathered layer of limestone.

As already stated the type locality of the member is in the bluff at old Arcola Landing on the Warrior River in the NE¼ sec. 4, T. 18 N., R. 3 E., Hale County, about 5 miles northeast of Demopolis. The description below is copied with modifications from the paper (96, pp. 1655-1657) in which the member was named.

Section at Arcola Landing, Warrior River, Hale County

	Feet
Selma chalk (Demopolis member):	
Brownish-gray shaly chalk containing scattered phosphatic nodules	6
Chalk containing abundant phosphatic nodules, phosphatic molds of mollusks, and occasional blocks of limestone up to 10 inches in length, derived by reworking from an underlying bed of limestone	1
Hard gray shaly chalk containing scattered phosphatic nodules	2
Disconformity or diastem (somewhat irregular).	
Selma chalk (Arcola limestone member):	
Hard limestone perforated with chalk-filled borings (bored rock)	1
Light-gray hard shaly chalk	2
Hard limestone perforated with chalk-filled borings; contains a thin chalky layer in the middle of the bed	2
Selma chalk (lower marly member):	
Hard light blue-gray chalk with several interbedded shaly layers	12
Concealed by muddy sediment to water level	3
	29

The section was described during a period of high water. The river stage at Demopolis on that day (April 28, 1938) was 42.2 feet; during normal low water of the fall months the stage is 12 or 13 feet.

The member is exposed near Arcola at the more accessible Hatchs Bluff, in sec. 3, T. 18 N., R. 3 E., but there it crops out at the top of the bluff (fig. 8) and the disconformity or diastem between the Arcola and Demopolis members is obscured by weathering.

Fig. 8.—Hatchs Bluff on the Black Warrior River, sec. 3, T. 18 N., R. 3 E., Hale County. The Arcola limestone member of the Selma chalk is exposed at the top of the bluff.

Northwest of Arcola Landing the member makes a prominent scarp across Greene County through Watsonia and south of Boligee where it passes under the alluvium of the Tombigbee River to reappear in the upland of Sumter County east of Panola.

In the eastern part of Hale County, particularly in sec. 24, T. 18 N., R. 5 E., the tops of the low mesas formed by the limestone have been scraped away to be crushed for road metal. Although it has long been used on the local roads, because of the scarcity of gravel, the rock is not entirely satisfactory, for in a few years it breaks down into a residual clay little better than the native prairie mud.

In the central part of Alabama the member is much thicker than it is farther west. As many as 4 layers of the limestone were seen in a local road cut just south of Alabama Highway 22 at the east edge of Beloit in the NW¼ NW¼ sec. 23, T. 16 N., R. 9 E., Dallas County.

Section south of Alabama Highway 22 at east edge of Beloit, Dallas County

	Feet
Selma chalk (Demopolis member):	
Medium-gray clayey chalk containing *Ostrea plumosa, O. panda* and other fossils; weathers to cream-colored clay; in basal foot are many phosphatic molds of mollusks and abundant specimens of *Exogyra ponderosa*	22.0
Disconformity or diastem.	
Selma chalk (Arcola limestone member):	
Hard light cream-colored perforated pure limestone	1.0
Soft cream-colored chalk	2.5
Hard cream-colored pure limestone perforated by borings	1.0
Soft cream-colored chalk	2.5
Hard perforated limestone	1.0
Soft marly chalk	5.0
Hard limestone (in highway cut)	2.0
	37.0

The bottom of this section probably is at the base of the Arcola limestone member, but the material below is covered by sod.

The member crops out in Hatchers Bluff on the Alabama River in sec. 36, T. 16 N., R. 10 E., Dallas County, about 30 feet below the top of the chalk exposed there or 50 feet below the top of the bluff. Because of high water this section could not be described in detail, but about 100 feet or more of the lower marly member of the Selma is exposed below the Arcola member.

The easternmost exposure of the characteristic limestone of the Arcola yet seen is in a shallow cut on the local road north of Downing near the center of sec. 26, T. 14 N., R. 20 E., Montgomery County, where a few blocks of very chalky and clayey limestone are exposed. Phosphatic molds are contained in the basal part of the overlying Demopolis member at the top of the hill on a T-road to the southwest.

In Bullock County the Arcola member is apparently represented by layers of soft sandstone and hard limestone beneath the Cusseta sand, but additional work is needed to trace these beds into the limestone to the west. Additional study may also confirm the suggestion already made that the hard limestone beds near the top of the Blufftown formation are the eastern continuation of the Arcola limestone member.

Thickness.—The Arcola limestone member is a very thin stratigraphic unit and except on large scale maps seldom can be shown without exaggeration. In Mississippi and probably in the extreme western part of Alabama it rarely exceeds 2 feet in thickness. At the type locality it is only 5 feet thick. The greatest observed thicknesses are in Dallas and Lowndes Counties where the member may slightly exceed 15 feet in thickness.

Little is known of the thickness of the member in the subsurface south of the belt of outcrop. The only available subsurface record of the limestone is in the log of the Livingston well (50, pp. 277-278) in which Dr. R. D. Webb, a local physician, recorded 6 or 8 inches of "hard, gritty, bluish colored rock, so hard that it had to be drilled." As most petroleum geologists are now looking for it in test wells drilled through the Selma it is likely that figures of its thickness down the dip will be available soon.

Stratigraphic relations.—The Arcola limestone member rests conformably on the lower marly member of the Selma chalk and except for convenience of discussion might be considered a part of that member. It is overlain with a sharp disconformity by the Demopolis member of the Selma chalk. The disconformity is characterized by a sharp contact at all fresh exposures, by borings into the Arcola member filled with the overlying chalk, and by a basal conglomerate in the Demopolis member consisting of numerous phosphatic molds of mollusks and reworked water-worn blocks of limestone.

The member merges laterally to the east into the upper part of the Blufftown formation and to the north in Mississippi into the Coffee sand. The Arcola member is near the middle of the *Exogyra ponderosa* zone. Correlations with formations in other States are made in the discussions of the stratigraphic relations of the lower marly member of the Selma chalk and the Blufftown formation and need not be repeated here.

Physiographic expression.—The hard limestone layers of the Arcola give rise to a prominent scarp in the gently rolling prairie underlain by the easily eroded marl and chalk of the Selma. The scarp, now generally called the Arcola scarp, represents the steep slope of a cuesta. Outliers of the scarp take the form of low mesas that are capped by one or more of the hard limestone layers. (See fig. 3). In many of the mesas and at most places on the scarp

each layer of the limestone makes a distinct bench. The scarp varies in height depending upon the relative relief of the surrounding prairie, being higher near the large rivers and lower on the uplands far from a major stream. In the region between Boligee and Forkland, where the Tombigbee River is only a few miles to the southwest the scarp is about a hundred feet high. In Perry County and in the western part of Dallas County, which are on the upland about midway between the Warrior and Alabama rivers, the scarp probably does not exceed 50 feet.

The Arcola scarp is easily traceable from the Mississippi State line in the southwestern part of Pickens County to the eastern edge of Montgomery County. In the central part of the State it is the most noticeable topographic feature in the Black Prairie belt.

Demopolis member of the Selma chalk

Name.—Smith (53, pp. 12-14) in 1903 divided the Selma chalk into three divisions: The upper or Portland division containing more than 25 percent of clay, the middle or Demopolis division containing less than 25 percent of clay, and the lower or Selma division containing more than 25 percent of clay. Apparently he originally intended to name the entire chalk formation in Alabama Demopolis for the legend on a base map of Alabama included in his report of progress for the years 1884-8 (44, map) shows the formations of the Cretaceous as Tuscaloosa, Eutaw, Demopolis (Rotten Limestone), and Eufaula (Ripley). Later consideration led him to adopt the name Selma.

Later workers did not follow Smith in his three fold division of the Selma, but recent work shows that subdivision of the Selma is not only practicable but desirable. In the present paper Smith's Selma division is represented almost exactly by the unnamed lower marly member of the Selma chalk but, as the name Selma chalk has long been firmly established for the formation as a whole, its additional use to designate a member of the same formation would be confusing and contrary to the rules for stratigraphic nomenclature. His Demopolis division is represented by the Arcola limestone member and lower part of the Demopolis member. His Portland division is represented in western Alabama by the upper part of the Demopolis member, the Ripley formation, and the

Prairie Bluff chalk, and in central Alabama by the upper part of the Demopolis member and the lower part of the Ripley formation. Specifically, in the present paper the Demopolis member of the Selma chalk includes all chalky and marly beds between the diastem above the Arcola limestone member (below) and the Ripley formation (above).

The type locality of the Demopolis member is the bluff of chalk on the Tombigbee River at Webb and Sons cotton warehouse in Demopolis, Marengo County, Alabama.

Areal extent.—The Demopolis member of the Selma chalk extends from the Mississippi State line in the southern part of Pickens County and the northern part of Sumter County southeastward in a belt of outcrop about 10 miles wide through Sumter, Greene, Marengo, Hale, Perry, Dallas, and Lowndes Counties. In the south-central part of Montgomery County the member is split into two eastward-extending tongues by a westward-extending tongue of the Cusseta sand. The lower tongue of the Demopolis member is very thin, but extends eastward beneath the overlying tongue of Cusseta sand entirely across Montgomery County to the western part of Bullock County. The upper tongue, which is much thicker, extends eastward through Fleta, becomes thinner toward the east, and near the village of Pine Level it merges into chalky sand and clay which for the present is considered a part of the Cusseta sand. This thin chalky bed, near the top of the Cusseta, extends eastward to the eastern part of Barbour County, but has not yet been recognized on the Chattahoochee River.

Lithologic character.—The lower part of the Demopolis member consists of marly chalk only slightly more chalky than the marl below the Arcola limestone member. This marly part, however, is very thin and is overlain by the purest part of the Selma chalk, which contains from 75 to 90 percent $CaCO_3$ according to analyses published by Smith (54, pp. 445-446). This pure chalk facies of the member merges upward into chalk containing more clay and sand which in turn is overlain rather abruptly by the Ripley formation. The upper part of the member, although less pure than the main body, consists of much purer chalk than the marl member below the Arcola limestone. The Demopolis member is weakly bedded in thick layers of chalk that vary slightly in hardness, but individual stratification lines are hard to find on close examination.

In the river bluffs, however, beds more resistant to weathering project slightly from the wall.

The purer part of the Demopolis member is typically exposed at the bluff on the Tombigbee River at Demopolis, Marengo County. In this bluff at Webb and Sons cotton warehouse, near the southern end of a sharp westward bend in the river, about 50 feet of pure, hard white chalk is exposed. The chalk contains the small fossils characteristic of this part of the member, *Diploschiza cretacea* and *Terebratulina filosa.* The outcrop is cut by several small faults that have little regularity of orientation. These small faults have openings filled by veins of calcite whose outer sides preserve slickensides perfectly. These calcite veins are characteristic features of this purer part of the chalk in western Alabama. The faults are all small and may represent only settling or minor movement accompanying the much more active movement in the Livingston fault zone in Sumter County.

Jones Bluff on the Tombigbee River at Epes, Sumter County (fig. 9) consists of about 80 feet of fairly pure, hard, white chalk

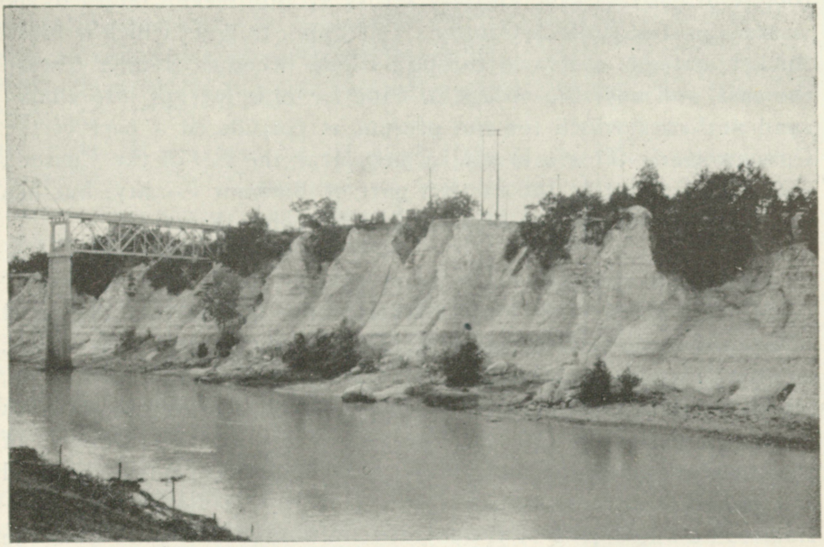

Fig. 9.—The Demopolis member of the Selma chalk at Jones Bluff on the Tombigbee River below the railroad bridge at Epes, Sumter County. Slight displacement of a projecting layer at the right of the photograph indicates a small fault.

containing somewhat harder beds that project slightly as ledges. *Diploschiza cretacea* and *Terebratulina filosa* are found in the lower part of the bluff to an altitude of about 110 feet above sea level (55 feet above low-water level). This chalk is of the same type and is at the same stratigraphic position as the chalk at the type locality at Demopolis.

The purer chalk of the Demopolis member characterized by the presence of *Diploschiza cretacea,* has been traced eastward from Demopolis to Montgomery County, as shown by the line of outcrop of the *D. cretacea* zone, "D" on the geologic map (pl. 1). The zone crops out on the Alabama River at Whites Bluff in sec. 15, T. 15 N., R. 9 E., Dallas County. The upper part of this bluff consists of hard somewhat marly chalk that does not contain *Diploschiza cretacea,* but about 90 feet below the top Mr. Brown and I found specimens of the fossil on July 7, 1940, at a time of high water on the Alabama River. The water was about 30 feet below this point, and much of the lower part of the bluff was concealed at the time of our visit.

This part of the member is less pure east of Dallas County but the *Diploschiza cretacea* zone has been traced entirely across Lowndes County into Montgomery County where the upper part of the zone forms the base of the upper tongue of the Demopolis member. *D. cretacea* has been collected in the lower part of this tongue at Fleta and at Ada in the NW¼ NE¼ sec. 17, T. 13 N., R. 18 E., but has not yet been found farther east. In the cut of the Luverne Branch of the Atlantic Coast Line Railroad at Ada about 15 feet of impure sandy clayey chalk is exposed. A few specimens of *D. cretacea* were collected in 1937 about 4 feet above the track level.

The more marly chalk below the typical beds of the Demopolis member contains the variety *Diploschiza cretacea striata* as high as 50 feet above the Arcola limestone member. The range of this variety has not yet been determined as accurately as the range of *Diploschiza cretacea,* but the variety has been found immediately above the diastem at the base of the Demopolis member and is abundant about 50 feet above the diastem. Mr. Brown found one specimen only 50 feet below the bottom of the *Diploschiza cretacea* zone half a mile south of Taylor Creek in the SW¼ SW¼ sec. 21, T. 20 N., R. 1 E., Greene County. This find suggests that the variety is present throughout nearly all of the lower part of the Demopolis member. *Diploschiza cretacea striata* has been collected at the following localities: Road cut on Ala-

bama Highway 17, 2 miles south of Dancy, in the SW¼ sec. 10, T. 23 N., R. 3 W., Sumter County; gullies at the top of a hill 50 feet above the Arcola limestone member on the Boligee-Forkland road near the center of sec. 14, T. 20 N., R. 1 E., Greene County; in a field northwest of Five Points on the Boligee-Forkland road a few feet above the Arcola limestone member in the SW¼ SW¼ sec. 4, T. 20 N., R. 1 E., Greene County; and in a field at the side of a local road about 2 miles southwest of Massillon about 12 feet above the top of the Arcola limestone member in the NE¼ NE¼ NE¼ sec. 36, T. 17 N., R. 7 E., Dallas County. The original specimens of the variety were collected by L. C. Johnson "from the prairies of Massillon", the exact location of which is not now known.

The marly beds at the base of the member extend eastward beneath a westward-extending tongue of the Cusseta sand, but become more sandy toward the east. In this region as elsewhere they are characterized at the base by a thin bed of phosphatic nodules and molds of fossils and by large water-worn specimens of *Exogyra ponderosa.*

Above the typical beds of the member that contain *Diploschiza cretacea* and *Terebratulina filosa* is a thick deposit of very pure, hard, white chalk that contains few fossils except the ubiquitous *Ostrea plumosa* and fragments of *Inoceramus.* This is the rock used for the manufacture of cement at the plant near Demopolis, and it is the part of the Selma that contains the highest percentage of calcium carbonate.

Nearly all of the mica seen in the Upper Cretaceous deposits in Alabama is muscovite, but in the ditch at the side of a secondary road about 3 miles east-southeast of Epes, Sumter County, in the NE¼ SW¼ NE¼ sec. 33, T. 20 N., R. 1 W., small flakes of biotite, some as large as 0.35 inch, were observed in pure, hard, white chalk associated with numerous nodules of iron pyrites. No glauconite is present, although Galliher (89) ascribes the formation of glauconite to alteration of biotite on a sulphurous sea bottom. C. S. Ross examined a sample of this chalk and found a little volcanic ash showing that the biotite may have been deposited as a part of an ash fall in Demopolis time. No bentonite has been reported at this stratigraphic position in the eastern Gulf region.

This pure chalk merges upward into slightly more clayey chalk that contains a large fauna in which *Exogyra cancellata* and *Anomia tellinoides* are restricted species. On the geologic map (pl. 1) the base of this less pure chalk corresponds closely with the line P which marks the outcrop of the plane dividing the *Exogyra ponderosa* zone from the overlying *Exogyra costata* zone. The bluff at old Bluffport on the Tombigbee River in sec. 26, T. 19 N., R. 1 W., Sumter County, is 180 feet high and includes all this part of the Demopolis member. Mr. Pierce found a specimen of *Anomia tellinoides* about 15 feet above low-water level of the Tombigbee River and this species and *Exogyra cancellata* are abundant about 100 feet above water level. The hills back of the bluff are capped by sand of the Ripley formation. Numerous faults cut the chalk in the bluff, but the displacement of beds is small.

The Demopolis member merges upward into the Ripley formation with no perceptible break, but the change from only slightly sandy chalk to chalky sand is abrupt enough in single exposures to enable the geologist to determine a boundary between the Selma and Ripley within a few feet.

In the western half of Sumter County the Demopolis member includes the entire *Exogyra cancellata* zone, but north of Coatopa the chalk in the upper half of the zone intertongues with sand of the Ripley formation, and east of Sumter County the member includes only about the lower half of the zone. A suggestion of the intertonguing is shown by exposures on the old Brewersville-Belmont road on a southwestward-facing slope in the SW¼ sec. 12, T. 18 N., R. 1 W., where, at the foot of the hill, Mr. Pierce found coarse-grained sandy chalk overlain by fine-grained sandy, micaceous, light-gray chalk. Both the coarse-grained and the fine-grained varieties contain *Exogyra cancellata*. The coarse-grained material is probably just beyond the western end of a tongue of the Ripley formation that is overlain by an eastward-extending tongue of the Demopolis member of the Selma.

Thickness.—No direct measurements of the thickness of the Demopolis member of the Selma chalk are available, but by subtracting the known thickness of other parts of the Upper Cretaceous series penetrated in the well at Livingston (43, p. 84; 50, pp. 277-278) it is possible to get an approximate figure of the thickness of the member. The Prairie Bluff chalk is about 80 feet thick

and the Ripley in Sumter County is about 100 feet thick. The well entered the Upper Cretaceous at a depth of 20 feet and reached the Arcola limestone member at a depth 690 feet. As it entered the top of the Selma chalk at about 200 feet, the thickness of the Demopolis member is about 490 feet. This compares favorably with estimates made by study of outcrops. The *Diploschiza cretacea* zone is about 60 feet thick in the western part of Alabama and appears to be about 150 feet above the base of the member. The *Exogyra cancellata* zone is in the upper 125 to 150 feet of the member in the western part of Sumter County and is probably in the upper 75 to 100 feet of the formation farther east where the zone is partly within the Ripley.

The belt of outcrop of the member is narrower in the western part of Montgomery County than it is farther west and the member may be thinner in that region, but I have no accurate data on its thickness there.

Stratigraphic relations.—The Demopolis member of the Selma chalk rests disconformably on the Arcola limestone member. The disconformity probably represents a very short time interval and might better be termed a diastem. It is characterized in fresh exposures by a sharp line of contact, by borings into the underlying material filled with the basal marl of the Demopolis, by a basal conglomerate in the Demopolis consisting of more or less water-worn blocks of Arcola limestone, phosphatic nodules and phosphatic internal molds of mollusks, and by abundant water-worn shells of *Exogyra ponderosa* and a few other oysters.

The member is overlain conformably by the Ripley formation as far east as the Montgomery-Lowndes county line. In the eastern part of Sumter County the upper part of the Demopolis member of western Sumter County and Mississippi intertongues with the Ripley formation with the result that the top of the member is at a slightly lower stratigraphic position farther east.

In Montgomery County the Demopolis member is split into two eastward-extending tongues by a westward-extending tongue of the Cusseta sand. The lower tongue of the Demopolis member is very thin and merges upward into the much thicker tongue of the Cusseta. Toward the east in Bullock County it merges laterally into the base of the Cusseta sand. The transition of the material between the two Demopolis tongues into the westward-extending

tongue of the Cusseta sand is gradational over a distance of about 5 miles laterally near the Lowndes-Montgomery County line and consequently cannot be mapped accurately. The tongue of Cusseta merges upward into the overlying tongue of Demopolis chalk, but the change is relatively abrupt and can be mapped reasonably accurately on small scale maps. The upper tongue of the Demopolis member includes the upper part of the *Diploschiza cretacea* zone, the overlying chalk that contains few fossils, and the lower part of the *Exogyra cancellata* zone.

Successively higher parts of the tongue of chalk or marl merge laterally into the underlying tongue of Cusseta sand toward the east causing the boundary between the two formations to rise to higher stratigraphic positions toward the east. In the east-central part of the county the contact of the two formations is near the top of the *Exogyra ponderosa* zone.

The uppermost strata of the Demopolis apparently merge laterally in the western part of Montgomery County into another westward-extending tongue of the Cusseta sand, and toward the east slightly lower beds merge into sand causing the boundary between the top of the tongue of Demopolis and the upper tongue of Cusseta to drop to a slightly lower stratigraphic position. At the eastern end of the tongue of Demopolis as mapped (pl. 1) the boundary between the upper tongue of the Demopolis and the upper tongue of the Cusseta sand is between 20 and 50 feet above the base of the *Exogyra cancellata* zone.

The upper tongue of the Demopolis member is represented in the Cusseta sand in Bullock County by chalky, clayey sand about 70 feet thick. This member of the Cusseta might be regarded as an eastern extension of the Demopolis tongue, but it has not been so mapped because the material is chalky sand rather than chalk or marl. If detailed studies are ever carried out in this region it may be advisable to treat this chalky sand as an extension of the Demopolis to avoid complications of mapping. The plane dividing the *Exogyra ponderosa* and *Exogyra costata* zones is near the middle of this calcareous member of the Cusseta.

The Demopolis member includes roughly the upper half of the *Exogyra ponderosa* zone and the lower quarter to the lower half of the *Exogyra costata* zone.

Narrowly restricted species of fossil shells permit accurate correlations of the Demopolis member with other formations in the western Gulf region and the Atlantic Coastal Plain. *Diploschiza cretacea minor* a form like *D. cretacea* but smaller, and *Terebratulina filosa* have been collected in the Annona chalk in northeastern Texas, in the Pecan Gap chalk member of the Taylor marl, and in the upper part of the Anacacho limestone, suggesting a close correlation of these formations with the part of the Demopolis member that contains *Diploschiza cretacea* and *Terebratulina filosa.*

Exogyra cancellata and *Anomia tellinoides* are restricted to the Saratoga chalk in Arkansas, the Neylandville marl in Texas, the lower part of the Peedee formation in the Carolinas, and the Mount Laurel sand in New Jersey.

The Demopolis member, then, is probably equivalent (100) in Texas to the upper part of the Anacacho limestone, the upper half or more of the Taylor marl, and the Neylandville marl; in Arkansas to the upper part of the Annona chalk, the Marlbrook marl, and the Saratoga chalk; in Mississippi to the upper part of the Coffee sand (that part represented by the Tupelo tongue) and the Selma chalk above the Arcola limestone member, but not including the upper sandy beds that have been included in the Ripley in the present report; in Georgia to the Cusseta sand; in the Carolinas to the upper half of the Black Creek formation and the lower part of the Peedee formation; and in New Jersey to the Englishtown sand, the Marshalltown formation, and the Wenonah sand of the Matawan group, and the Mount Laurel sand of the Monmouth group. Dr. Stephenson (100) believes that the formation represents the upper part of the Campanian and the lower part of the Maestrichtian stages in the European section.

Physiographic expression.—The Demopolis member forms the surface of the middle and southern parts of the Black Prairie belt. The lower part of the member forms the back slope of the Arcola cuesta and gives rise to typical black prairie soil. The purer, middle part of the member on the other hand gives rise to so little soil on weathering that large bare patches of chalk, termed bald spots, are common. (See fig. 4). The topography of this section of the Black Prairie belt is gently rolling like that to the north, but the general appearance of the country is in marked contrast because of the scarcity of black soil and the abundance of the glaringly white

bald spots. Cedar trees seem able to grow upon very little soil and are common in this part of the prairie.

The upper, more marly part of the Demopolis member forms the surface in the foothills of the Chunnennuggee Hills to the south, a much more rolling country than the belt of bald spots to the north. The southern edge of the belt of outcrop of the member is in the lower slopes of the High Ridge cuesta scarp caused by the overlying Ripley formation.

Slopes as gentle as 1 percent are common in the purer, middle part of the member except near the major rivers, but in the more marly upper part of the formation the slopes average about 5 percent, with steeper slopes not uncommon. The maximum relief on the upland in the middle part of the member is about 50 feet in a square mile and in the upper part the average relief is about 100 feet. This greater relief and slope angle in the marly upper part is due more to the proximity of the High Ridge cuesta than to any inherent quality of the chalk.

BLUFFTOWN FORMATION

Name.—In 1909 Veatch (62, pp. 86-89) divided the Ripley formation of Langdon (45, pp. 587-605; 47, pp. 90-94; and 50, pp. 423-426) into four units: "Lower (Blufftown) marl, 200 feet; Middle (Cusseta) sand (unconsolidated), 250 feet; Upper (Renfroes) marl, 500 feet; and Upper sand (Providence) unconsolidated, 150 feet." Stephenson (65, p. 72) in 1911 adopted a different classification of the deposits along the Chattahoochee River. He says:

> [Veatch's] usage of names for Ripley subdivisions as compared with that adopted for the present report, is explained as follows: The "Blufftown marl" corresponds to the Tombigbee sand member of the Eutaw formation and to a part of the overlying Ripley formation; the Cusseta sand is the Cusseta sand member of the Ripley formation; the "Renfroes marl" is composed of characteristic Ripley materials and requires no special membership designation; and the Providence sand becomes the Providence sand member of the Ripley formation.

Later faunal studies by Stephenson convinced him that the strata he had assigned to the "basal beds of the Eutaw formation" in the Chattahoochee River region (69, p. 25) are actually equivalent to the Tombigbee sand member of the Eutaw formation; and

that the overlying strata that he had previously (65, p. 112; 69, pp. 20, 21) considered Eutaw (including the Tombigbee sand member) are actually equivalent to the lower part of the Selma chalk. Accordingly in the fall of 1937 he suggested that an attempt be made to trace eastward in Alabama the divisions of the Selma chalk previously mapped in Mississippi, determining the lateral changes in lithologic character. The basal phosphatic zone of the Selma chalk was traced eastward into Macon County, Alabama, where two phosphatic zones were found—one at the base of the Selma as developed in that county and in Russell County to the east, the other at the base of the medium-grained glauconitic sand that underlies the marl. The lower phosphatic bed was apparently equivalent to a fine gravel bed cropping out near Uchee, Russell County, and farther east, but the upper phosphatic bed could be traced only as far as the marl of the Selma in central Russell County. Whether either horizon marked the contact of the Eutaw and "Selma" formations was not determined. In the spring of 1938 all the localities found the preceding fall were revisited with Dr. Stephenson and he was able to prove convincingly that the lower bed represented the base of a sand formation equivalent to the Selma chalk farther west. Veatch's name Blufftown was revived, therefore, to designate all strata between the Eutaw formation (below) and the Cusseta sand (above) (96, pp. 1648-1649). The type locality is at old Blufftown on the Chattahoochee River in Stewart County, Georgia.

Areal extent.—The Blufftown formation is exposed on the bluffs of the Chattahoochee River from Moores Rocks (18 miles below Columbus) south to Woolridge Landing (46½ miles below Columbus, 13½ miles above Eufaula). Throughout much of this extent, particularly below Blufftown (31¼ miles below Columbus) the Cusseta sand is exposed on the higher bluffs, for the course of the river approximates the strike of the formations for many miles below Blufftown.

Toward the west in central Russell County the Blufftown formation is divided into two westward-extending tongues by an eastward-extending tongue of the lower marly member of the Selma chalk. The lower tongue of the Blufftown formation can be traced westward through the southern part of Macon County to the vicinity of Hardaway, where it merges into the lower part of the Selma chalk. At the Macon-Russell County line the line of

outcrop of the top boundary of this tongue bends southeastward, because of deep trenching by the Chattahoochee River drainage, and follows the southwest (right) bank of the North Fork of Cowikee Creek. The overlying tongue of marl of the Selma chalk merges into noncalcareous strata in the eastern parts of T. 14 N., R. 27 E., Russell County, and T. 13 N., R. 27 E., Barbour County. Outliers of the Selma overlie the tongue of Blufftown between two branches of the North Fork of Cowikee Creek east of Hurtsboro and between Cowikee and Hatchechubbee Creeks (see map, pl. 1).

The upper tongue of the Blufftown formation that overlies the lower marly member of the Selma chalk has been traced westward through northern Bullock County a few miles west of Union Springs where it merges into sandy marl that is designated Selma. The lower contact of this tongue and the underlying marl is so gradational that the boundary shown on the geologic map (pl. 1) has been arbitrarily drawn within the transition zone. The top contact of the tongue is sharp and is found directly underlying the Cusseta sand near the crest of the Enon cuesta. At Enon the contact bends sharply south because of deep incision of the Chattahoochee drainage. The contact is recognizable east of Midway and appears to bend southeast, east and northeast around the Comer salient, trending northeast from Batesville across the drainage of Cowikee Creek. The upper tongue is concealed by outliers of Cusseta sand on the ridge between the Middle and South Forks of Cowikee Creek. Locally between Comer and Spring Hill (Cowikee P. O.), Barbour County, the outcrop is interrupted by a large inlier of the lower marly member of the Selma chalk that has been exposed by the deep incision of the drainage of the South Fork of Cowikee Creek and its tributaries.

Cooke (97) has traced the Blufftown toward the northeast in Georgia as far as the central part of Marion County, about 23 miles east of the Chattahoochee River.

Lithologic character.—The Blufftown formation is made up of marine deposits including near-shore coarse sand and fine gravel at the base, overlain by clayey fossiliferous fine sand. East of the tongue of Selma marl this fine sand is overlain by the clayey extension of the marl, which in turn is overlain by highly fossiliferous very fine silty sand.

As I have examined the strata of the Blufftown formation at only a few places on the Chattahoochee River, including the type locality at old Blufftown, Stewart County, Georgia (fig. 10), where at least 95 feet of fossiliferous sand and clay is exposed (65, pp. 135-137), Langdon's carefully measured section of strata exposed on the river is quoted below.

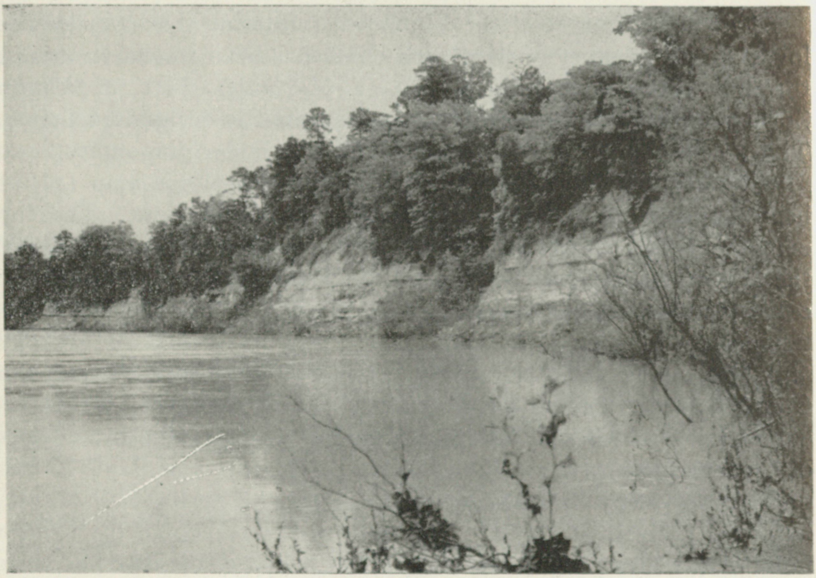

Fig. 10.—Bluff on left bank of the Chattahoochee River at the site of old Blufftown in Stewart County, Georgia. The type locality of the Blufftown formation.

Beds 10 to 16 of Langdon's description are tentatively assigned to the Blufftown formation and are given here in descending order.

Part of Langdon's description of strata exposed on the Chattahoochee River (50, pp. 440-441) including beds of supposed Blufftown age

		Feet
16.	Gray and yellow sands, resembling in physical character those of the Tertiary at Lower Peach Tree, Alabama	30
15.	Gray calcareous sands, containing a small, fragile *Anomia* and a line of hard, round concretionary bowlders	40
14.	Two miles above Florence, Georgia, and making part of a bluff 50 feet high at that place, there is a gray sand interlaminated with thin seams of a more argillaceous sand, all of which is unfossiliferous. Dip here about 40 feet to the mile	26
13.	Gray, sandy calcareous clay, with lines of bowlder-like concretions projecting from the bank; first seen at Lawson's wood yard, Georgia. Few fossils occur in the lower part of this stratum, *Exogyra costata,* Say [*E. ponderosa* Roemer], a mile above Blufftown, Georgia, where characteristic Ripley shells, mainly bivalves, are found in a much decomposed state throughout a stratum 6 to 8 feet thick. The uppermost 10 feet of the stratum is very fossiliferous. The river washes out little cave like recesses in the banks. Near Jernigan's landing, Alabama, slight rolls in the strata are seen, involving about 20 feet of the sands, and these miniature anticlinals and synclinals continue to within two miles of Florence, Georgia. The dip, estimated from the line of bowlders, averages about 20 feet to the mile and is normal in direction	120
12.	Light-yellow and white sands, containing beds of well-rounded quartzose pebbles, sometimes 20 feet thick. Lignitized logs can be seen protruding from the bluffs. The sands contain a small *Exogyra* at rare intervals. The supposed top of the Eutaw group [?]	45
11.	Yellow sand and gray clay, containing bits of leaves. This stratum and the following [overlying] are seen at Chimney Bluff, Georgia	60
10.	Quartzose conglomerate much like that at Havana, Hale County, Alabama; forms the shoal at Beden's rock and the bluff at Hatcher's lower landing; merges gradually into a yellow sand	50
		371

It will be seen from the section above that the Blufftown formation now (96) includes the upper 155 feet of Langdon's Eutaw group and the lower 216 feet of his Ripley group. It is likely that future work will show that Langdon's section needs revision for he apparently was not aware that the dip of the strata is southeast on Chattahoochee River rather than south as it is farther west in Alabama; some of his thicknesses, therefore, may not be correct.

The westernmost point at which the contact of the Blufftown with the underlying Eutaw formation was observed is in a shallow road cut on the eastward-facing slope of the valley of a small branch of Cubahatchee Creek in the NW¼ sec. 7, T. 15 N., R., 23 E., about 2½ miles north by west of Downs, Macon County.

Section 2½ miles north by west of Downs, Macon County

	Feet
Blufftown formation:	
Chalky, silty, finely sandy clay containing phosphatic molds of mollusks; at base is a bed of water-worn cobbles of calcareous sandstone, some of which have oyster shells attached to them	9.0
Disconformity.	
Eutaw formation:	
Slightly indurated sandstone	0.5
Soft yellow fossiliferous clayey sand containing soft nodular concretions up to 6 inches in diameter	5.0
Hard sandstone, irregular base and top	1.0
Soft yellow clayey sand	2.0
Hard sandstone	1.0
Soft yellow clayey sand	1.5
	20.0

The lower beds of this chalky facies of the Blufftown formation are well exposed two miles due west of the outcrop just mentioned in a deep road cut on the northward-facing slope of Cubahatchee Creek Valley in the SW¼ NW¼ sec. 11, T. 15 N., R. 22 E., 1½ miles northeast of Hardaway, Macon County, but the underlying Eutaw formation was not seen.

Section of Blufftown formation, 1½ miles northeast of Hardaway, Macon County

	Feet
Gray sandy clay soil	4.0
Yellow and very light-gray slightly calcareous, clayey, silty, fossiliferous very fine-grained sand containing several indurated layers including one at top	21.0
Hard calcareous, very finely sandy siltstone	1.5
Light-tan silty and very finely sandy clay containing many phosphatic molds of mollusks and small phosphatic pellets; lower part contains water-worn cobbles of hard concretionary sandy limestone apparently somewhat phosphatic; this is probably basal bed of the Blufftown formation	2.0
Concealed by soil to foot of hill	10.0
	38.5

The easternmost exposure in which phosphatic material was found at the base of the Blufftown is on U. S. Highway 43 just south of Calebee Creek Valley in the SE¼ SE¼ sec. 6, T. 15 N., R. 24 E., 4¾ miles by road north-northeast of Fort Davis, and 1½ miles south by west of Mount Nebo Church, Macon County, where the following section is exposed in a shallow road cut:

Section on west side of cut of U. S. Highway 43 south of Calebee Creek, Macon County

	Feet
Blufftown formation:	
Gray and tan slightly micaceous, silty, very finely sandy clay merging upward into reddish brown soil	6.0
Slightly indurated clayey sand	0.5
Micaceous, clayey fine sand containing discontinuous indurated layers	2.5
Micaceous, clayey, calcareous fine sand containing abundant phosphatic molds, and shells of *Ostrea cretacea* and *Gryphaea* sp.; a few water-worn cobbles at base	1.0
Disconformity (sharp contact).	
Eutaw formation:	
Compact gray and light-brown slightly clayey, micaceous fine sand	3.0
Very hard very calcareous very fine-grained sandstone	1.0
	14.0

East of the highway the contact was not seen in Macon County, but it could be located reasonably accurately, for both Warrior Stand and Creek Stand are situated on red sand that is the weathered product of the lower part of the Blufftown formation, whereas about 2 miles north of Warrior Stand and Creek Stand a bed of fine sand filled with *Ostrea cretacea* crops out. This bed is prominent in the Eutaw formation farther east in Russell County.

In Russell County the westernmost exposure of the contact thus far seen is in a cut of a secondary road on the westward-facing slope of Hatchechubbee Creek in the NE¼ SW¼ sec. 19, T. 16 N., R. 27 E., a mile west of Uchee.

Section a mile west of Uchee, Russell County

	Feet
Blufftown formation:	
Gray and red sandy clay merging downward into finely micaceous, clayey very fine sand containing abundant perfect prints of fossils; much fine gravel at base and at some places thin lenses of red sand and fine gravel a foot above the base	19.0
Cross-bedded white coarsely micaceous, arkosic coarse sand containing small subangular quartz pebbles; top perforated by borings and small potholes filled with overlying material	6.5
Disconformity.	
Eutaw formation:	
Blue-gray micaceous, clayey very fine sand containing prints of fossils; the upper part has been weathered to pink; to floodplain of branch	5.0
	30.5

The coarse sand and fine gravel that marks the base of the Blufftown has been traced eastward from Uchee to the Chattahoochee River, where it forms bed 10 of Langdon's section (50, p. 440). It forms the cap of the cuesta scarp of the Sand Fort cuesta, but has previously been considered "Lafayette" by Smith, Johnson, and Langdon (50, p. 563) and other workers. A gravel pit a few hundred feet north of Sand Fort in the SW¼ SW¼ sec. 27, T. 16 N., R. 28 E., shows a section of 28 feet of coarse red sand of which the lower 5 feet contains very coarse arkosic quartz sand and fine gravel; this exposure is about 40 feet above the oyster bed in the Eutaw formation, but the contact may be less than 40 feet below the base of the exposure.

In road cuts half a mile south of Nuckolls Mill in the SE¼ SE¼ sec. 31, T. 16 N., R. 30 E., Russell County, the contact between cross-bedded fine sand of the Eutaw formation and red coarse sand and fine gravel of the Blufftown formation is very irregular and undulating to a maximum of 5 feet. The actual contact of the two formations was not seen on the Columbus-Seale road (U. S. Highway 241), but at the foot of the slope south of Uchee Creek the oyster bed of the Eutaw formation is exposed and at the top of the hill the fine gravel of the lower part of the Blufftown is prominent.

The contact of the lower tongue of Blufftown with the overlying marl of the Selma chalk is well exposed at several places in

western Russell County. On Alabama Highway 26 a cut on the eastward-facing slope of the North Fork of Cowikee Creek in the NW¼ SW¼ sec. 29, T. 15 N., R. 27 E., about 3 miles east by north of Hurtsboro shows the contact plainly.

Section on Alabama Highway 26 about 3 miles east by north of Hurtsboro, Russell County

	Feet
Selma chalk (lower marly member):	
Light-brown and gray sandy, micaceous marl containing *Exogyra ponderosa* and *Ostrea plumosa;* lower 5 feet also contains *Pecten* (*Neithea*) sp.	19
Soft brown sandstone containing *E. ponderosa*, an echinoid, and phosphatic molds of mollusks	1
Blufftown formation (lower tongue):	
Light-yellow fine sand containing *E. ponderosa, O. elegantula,* and *P.* (*Neithea*) sp.; base about 5 feet above flood plain	5
	25

This is one of the three places in Alabama where *Ostrea elegantula* has been collected. As explained by Stephenson (92, pp. 2, 7, 8) this oyster suggests a correlation of the lower middle part of the Blufftown with the upper part of the Mancos shale and the basal part of the Mesaverde formation in New Mexico, with Upper Cretaceous strata in Presidio County, Texas, and with the upper part of the Blossom sand in Red River County, Texas. The other two places in Alabama from which it has been collected are in a railroad cut of the Central of Georgia Railway half a mile east of Hatchechubbee and in a shallow road cut of Alabama Highway 26 at the foot of the slope west of High Log Creek, 1½ miles west of Hatchechubbee.

A section very much like the one described above is exposed half a mile north of Alabama Highway 26 north of Hurtsboro on a local road in the SW¼ SW¼ sec. 26, T. 15 N., R. 26 E. There only 6 feet of the overlying marl is present, but phosphatic molds are abundant.

As explained above the lower tongue of the Blufftown becomes more chalky in its westward extension in Macon County and the last fairly sharp contact between the tongue and the overlying marl thus far observed is in sec. 18, T. 15 N., R. 24 E., about half a

mile east of Bethlehem Church. There 8 feet of sandy marl containing scattered phosphatic molds overlies 9 feet of very glauconitic marly sand. This lower glauconitic sand is much better exposed in the deep cut of a secondary road at Cotton Valley Cemetery a hundred feet east of U. S. Highway 29 in the SW¼ SW¼ sec. 7, T. 15 N., R. 24 E.

Section at Cotton Valley Cemetery, 10¼ miles south of Tuskegee, Macon County

	Feet
Blufftown formation:	
Brown highly glauconitic, clayey fine sand; lower part contains numerous tubes or borings preserved as clay films	22
Blue-gray soft calcareous, highly glauconitic sandstone	1
Blue-gray very clayey, highly glauconitic sand containing *Exogyra ponderosa* and *E. upatoiensis* Stephenson	6
	29

On the old Tuskegee-Union Springs road 1½ miles north by west of Cotton Valley Cemetery in the SE¼ sec. 1, T. 15 N., R. 23 E., a two-foot bed of impure bentonite is exposed in a shallow road cut in sand of the Blufftown. This is the only deposit of bentonite thus far seen in the Blufftown formation.

The eastward-extending tongue of marl merges imperceptibly into clay in the country south of Hatchechubbee. This gray clay, which contains a few calcareous nodules, has been observed on U. S. Highway 241 from 2 to 5 miles south of Seale, about 2 miles west of Glenville in sec. 11, T. 13 N., R. 28 E., and at a few other places along the line of strike of the tongue of marl.

The contact of the marl with the overlying tongue of Blufftown has not been seen at any place, probably because the change upward from marl to sand is gradational. For the purposes of the geologic map (pl. 1) the contact can be drawn approximately by noting the change from marl to sand, but no accurate boundary line can be drawn. Union Springs is near the western end of this tongue of sand, where the sand is merging laterally into marl. The section on U. S. Highway 29 on the steep northward-facing slope of the Enon cuesta at Union Springs shows a very calcareous facies of the Blufftown.

Section on U. S. Highway 29 at the north edge of Union Springs, Bullock County

	Feet
Cusseta sand:	
Very compact more or less cross-bedded gray and red coarse sand containing in basal 4 feet much gravel of pebbles up to 1½ inches long	15
Disconformity (very irregular contact).	
Blufftown formation:	
White, yellow, and pink cross-bedded finely micaceous fine to very fine sand	12
Concealed by loose sand	8
Light-gray and yellow very fine sand containing flakes of brownish-gray clay; contains numerous impressions of pelecypods	7
Highly cross-bedded yellow sand locally indurated to calcareous sandstone; contains a thin lens of lignite at one place; contains impressions of pelecypods	2
Light-brown fine sand and gray clay	3
Hard calcareous micaceous sandstone containing impressions of pelecypods	1
Weathered gray sandy clay containing a few calcareous nodules	9
Concealed by soil	16
Gray and brown finely sandy, micaceous, very calcareous clay containing abundant shark teeth, *Exogyra ponderosa, Ostrea plumosa, Anomia argentaria;* contains a few phosphatic bone fragments and some chalky molds of fossils; a little gypsum	10
Soft limestone	1
Calcareous, micaceous, clayey very fine sand	7
Concealed by soil	10
Soft highly micaceous, chalky sand containing shark teeth, *Anomia argentaria, Exogyra* sp.; a small sandstone dike crosses the outcrop just above a thin layer of chalky sandstone	44
Concealed by soil to flood plain of Town Creek	19
	164

It is questionable whether some of the beds in this section should be designated "Blufftown formation" or "Selma chalk", for lithologically they are near the borderline between the two formations. The hard calcareous sandstone beds near the top of the Blufftown occupy about the same stratigraphic position as the Arcola limestone member of the Selma chalk, but they have not been traced into that member.

A section of Blufftown similar to the preceding is exposed on the westward-facing slope of the Enon cuesta on Alabama Highway 6 at the southwestern edge of Union Springs.

Lateral changes in the character of the Blufftown formation can be detected by comparing the section described above with the one exposed from 1½ to 2 miles south of Suspension on the Enon cuesta (locally called Spann Hill) in sec. 19, T. 14 N., R. 25 E., Bullock County.

Section on Spann Hill, Bullock County

	Feet
Cusseta sand:	
Red coarse sand and fine gravel containing large tubes of coarse leached white sand; ferruginous sandstone at base	25.0
Disconformity.	
Blufftown formation:	
Ferruginous very fine sand interbedded with white sand and light blue-white clay; the sand contains obscure impressions of pelecypods	3.5
Stratified light brownish-gray micaceous, finely sandy clay; tongues into lenses of yellow and white mealy very fine sand containing abundant prints of pelecypods	11.0
Light-gray and yellow micaceous fine sand containing flaky dark-gray clay lenses and much comminuted plant material; contains prints of pelecypods	5.5
Light brownish-gray tough very fine sand containing flakes of comminuted plant material; abundant prints of pelecypods	8.0
Dark-gray concretionary limestone containing abundant prints of fossils	2.0
Brown very micaceous, very finely sandy clay, numerous prints of fossils; in part concealed by soil	6.0
Hard concretionary limestone passing laterally into thin-bedded sand locally indurated into half-inch layers that can be bent slightly like flexible sandstone or itacolumite; noticed a seam of parallel prisms of calcite; contains *Trigonarca maconensis* and abundant other fossils	5
Thin-bedded sand	5
Mostly concealed, but containing large blocks of limestone that may have fallen from above	34
Brown and gray micaceous, very finely sandy clay merging downward with no perceptible contact into brown calcareous clay full of soft calcareous concretions	29
Concealed on long gentle slope by red and gray leached sand; to bottom of branch (aneroid reading)	50
	184

Trigonarca maconensis has been found at many localities in the Blufftown formation, particularly near the top, and in the immediately overlying Cusseta sand. Other noteworthy localities are the Central of Georgia Railway cut down the Enon cuesta scarp

half a mile north of Peachburg, Bullock County, at Woolridge Landing (sec. 18, T. 12 N., R. 30 E.) and lower Roods Bend (sec. 17, T. 12 N., R. 30 E.) on the Chattahoochee River, and at a locality whose stratigraphic position is not clear—in the bank of a stream at the Central of Georgia Railway a mile southwest of Hatchechubbee, Russell County.

Prismatic calcite crystals like those seen on Spann Hill form the outer layer on concretions near the top of the Blufftown formation in the bank of the North Fork of Cowikee Creek, in sec. 7, T. 12 N., R. 28 E., Barbour County. Dr. Stephenson suggested to me that these concretions may prove to be the markers of a traceable horizon in the Blufftown formation.

Sections similar to that on Spann Hill are exposed along the Enon cuesta scarp near Enon and to the south where drainage of the Middle Fork of Cowikee Creek has cut back the hills, causing the cuesta scarp to bend from east to due south.

The drainage of the South Fork of Cowikee Creek has deeply incised the back slope of the Enon cuesta between Midway and Comer and there are many exposures of the upper Blufftown in this region. One of the best exposures of the upper contact of the formation is in a cut on Alabama Highway 6 about a mile east of Midway:

Section a mile east of Midway, Bullock County

	Feet
Cusseta sand:	
Red and yellow coarse sand containing small pebbles up to an inch in diameter	10
Disconformity.	
Blufftown formation:	
Dark blue-gray clayey, micaceous plastic very fine sand weathering to red and gray clayey sand	17
Weathered yellow very fine sand filled with well-preserved prints of pelecypods and gastropods	11
	38

The base of this exposure is 60 feet (aneroid) above the bottom of the branch to the east.

A few additional descriptions of the contact of the Blufftown with the overlying Cusseta sand are included in the discussion of the lithologic character of the Cusseta sand.

Thickness.—The portion of Langdon's section along Chattahoochee River (50, pp. 440-441) that is here included within the Blufftown formation has a total thickness of 371 feet. In June and July, 1940, many aneroid observations were made of contacts of different parts of the Blufftown to determine the dip and thickness of the beds. For the section between the contact of the Eutaw and Blufftown formations west of Uchee and the contact of the Cusseta and Blufftown formations on Spring Hill ridge near Taylor's store in sec. 13, T. 13 N., R. 26 E., the following approximate thicknesses were obtained: The lower tongue of the Blufftown formation appears to be about 65 feet thick; the eastward-extending tongue of the Selma chalk about 140 feet thick; and the upper tongue of the Blufftown formation about 175 feet thick. The total thickness of the Blufftown, would, then, seem to be about 380 feet, which is very close to Langdon's figure of 371 feet. It should be stressed that the method used in obtaining these figures is very rough and that they should be considered only approximations.

This thickness is notably greater than that of the part of the Selma chalk up to and including the Arcola limestone member in western Alabama and adjacent parts of Mississippi, where the member as measured in many wells is about 265 feet thick, but it is less than the probable thickness of this part of the Selma in Montgomery County.

Stratigraphic relations.—The Blufftown formation rests disconformably on the Eutaw formation, but little time is believed to be represented by the hiatus between the two formations, for similar fossils are found in both. The Blufftown is overlain with a very marked disconformity by the Cusseta sand, and at the eastern boundary of Alabama there is some suggestion of an overlap of the Blufftown by the Cusseta. Farther east in Georgia the entire Blufftown formation and also the Eutaw formation are completely overlapped by the Cusseta sand. According to Cooke (97) the Cusseta sand rests upon the Tuscaloosa east of the central part of Marion County, Georgia.

The Blufftown formation intertongues to the west with the lower marly member of the Selma chalk. A lower tongue, con-

sisting of about the lower 65 feet of the formation, merges into the marl between Hatchechubbee, Russell County, and Hardaway, Macon County. Conditions favorable to the deposition of sand, rather than marl, extended farther west at the beginning of deposition of the tongue than at later periods, so that at successively higher stratigraphic stages the lateral sand-marl boundary is found consistently farther east. The tongue of marl extends as far east as the longitude of Hatchechubbee, where it merges imperceptibly into gray clay. An upper tongue of sand extends west from Hatchechubbee to a point a few miles west of Union Springs, and shows a reversal in the sedimentation in that at successively higher stratigraphic stages the sand-marl boundary is found consistently farther west.

The stratigraphic relations of the Blufftown formation in western Georgia are similar to those in eastern Alabama, except that toward the east successively lower parts of the formation are overlapped by the Cusseta sand until in the central part of Marion County the entire formation is concealed by the overlapping sand.

In Mississippi the equivalent of the Blufftown formation, the part of the Selma chalk up to and including the Arcola limestone member, merges into the lower two thirds of the Coffee sand near Mooreville, Lee County. The Coffee sand extends northward into Tennessee, where in the middle of the State, it pinches out against the Paleozoic basement rocks.

The Blufftown formation embraces about the lower half of the *Exogyra ponderosa* zone, but the fossils have not been studied systematically, and therefore fullest use cannot be made of the fossil evidence.

The small oyster, *Ostrea elegantula,* found about 65 feet above the base of the formation is also found in the upper part of the Mancos shale and the lower part of the Mesaverde formation in New Mexico, in overturned Upper Cretaceous beds in Presidio County, Texas, and in the upper part of the Blossom sand in Red River County, Texas (92, pp. 7-8).

On the basis of this correlation it would seem that the Blufftown formation is equivalent to the upper part of the Austin chalk, the upper part of the Bonham marl, the Blossom sand, the Brownstown marl, and the lower part of the Taylor marl in Texas; the

upper part of the Tokio formation, the Brownstown marl, the Ozan formation, and perhaps the lower part of the Annona chalk in Arkansas. Dr. Stephenson (100) correlates the formation with the Merchantville and Woodbury clays of the Matawan group in New Jersey. In terms of the European section he believes that the formation is equivalent to the upper part of the Santonian and the lower part of the Campanian stages.

Physiographic expression.—The area of outcrop of the Blufftown formation includes the northeastern part of the Chunnennuggee Hills. The most prominent feature in this region is the Sand Fort cuesta that forms a steep northward-facing scarp overlooking the valley of Uchee Creek and the lowland to the north in Russell County, and the rather ragged scarp in Macon County that forms the divide between Calebee and Opintlocco Creeks in the eastern part of the county and the divide between Cubahatchee and Calebee Creeks in the central part. The cuesta scarp is about 200 feet high in Russell County but as the formation becomes more marly toward the west it is lower and in the vicinity of Hardaway is scarcely perceptible.

South of the crest of the cuesta the land slopes southward at a rate a little less than the dip of the formation and consists of gently rolling hills except near the main streams where beds harder than the rest of the formation give rise to slightly higher hills. In the belt of clay that might be considered the eastern remnant of the tongue of the marly member of the Selma the surface relief is slight and low "hog wallow" land is the rule.

South of the tongue of Selma the upper tongue of the Blufftown gives rise to gently rolling hills in contrast to the flatter country underlain by the marl. This is especially noticeable near Suspension and in the hills south of Comer.

The uppermost part of the formation is high on the slopes of the Enon cuesta scarp except where streams, such as Hatchechubbee and Cowikee Creeks, have cut through the scarp. The Enon cuesta is the most prominent scarp in the region and will be described more fully in the section dealing with the physiographic expression of the Cusseta sand, the basal beds of which form the resistant layer that causes the cuesta. The scarp is well seen north of Union Springs and south of Suspension, Bullock County, west of Glenville, Russell County, and along the north side of Spring Hill (Cowikee P. O.) in Barbour County.

CUSSETA SAND

Name.—Veatch (62, pp. 86-89) in 1909 designated the middle unconsolidated sand of the Ripley as defined by Langdon (50, pp. 423-426, see also 45 and 47) the Cusseta sand. In 1911 Stephenson (65, pp. 72, 152) applied this name to the basal member of his Ripley formation. In recent studies (96, pp. 1649-1650) it has been found that the Cusseta is separated from the underlying Blufftown formation and the overlying Ripley formation by disconformities, and the unit is now given formational rank.

The type locality has been designated by Stephenson (65, p. 162) as railroad cuts between Cusseta and Manta on the Seaboard Air Line Railway in Chattahoochee County, Georgia.

Areal extent.—On the Chattahoochee River the Cusseta first appears near the top of the bluff at old Blufftown, Stewart County, Georgia, (across the river from sec. 18, T. 14 N., R. 31 E.) and may be seen at many of the bluffs farther down the river, finally reaching water level just below Woolridge Landing (sec. 18, T. 12 N., R. 30 E., Barbour County). The formation crops out in bluffs on the river from Woolridge Landing to some point a short distance below the mouth of Cowikee Creek, where it is believed to pass below water level underneath the overlying Ripley formation. I have not seen these exposures, but from published descriptions and from outcrops a few miles west of the river in Barbour County, the contact between the two formations is believed to be at some point not far from where it is drawn on the geologic map (pl. 1).

For so thin a formation the belt of outcrop is remarkably wide in southeastern Russell County and northeastern Barbour County because the land surface slopes toward the Chattahoochee River at nearly the same rate as the dip of the formation. This dip-slope is interrupted by the drainage of the South Fork of Cowikee Creek, which has cut a deep valley through the Cusseta sand. It has exposed the underlying upper tongue of the Blufftown formation and, in the vicinity of Comer, the eastward extending tongue of the lower marly member of the Selma chalk. The narrowest part of the belt of outcrop of the Cusseta is southeast of Batesville, where the base of the formation is low on the hills south of the South Fork of Cowikee Creek and the contact of the Cusseta and the overlying Ripley formation is not far above

the bottom of Chewalla Creek Valley. A line of outliers of the Cusseta sand follows the ridge top between the drainage of the Middle and South Forks of Cowikee Creek, and at some time not far in the geologic past this ridge (Spring Hill) must have had a continuous mantle of Cusseta.

The formation has its greatest width of outcrop, 14 miles, in the southeastern part of Bullock County, where the Cusseta sand is exposed on an almost perfect dip-slope from the top of the Enon cuesta southward along the drainage of the headwaters of the Pea River. The base of the formation extends westward with minor irregularities along the divide between the drainages of the Pea and Conecuh Rivers to the south and the Chattahoochee and Alabama Rivers to the north, to Union Springs. West of Union Springs branches of Oakfuskee Creek which flows north to the Tallapoosa River have pushed the divide between the Conecuh and Alabama nearly 10 miles farther south than at Union Springs. In this region the "Chunnennuggee Ridge" of earlier writers makes a sharp bend south from the Enon cuesta to the High Ridge cuesta. From this southward-trending divide westward to the Montgomery County line the northern edge of the outcrop of the Cusseta sand is at a lower altitude than at Union Springs, but the southern part is at about the same altitude as at Indian Creek in southeastern Bullock County.

In Montgomery County the Cusseta sand is divided into two westward-extending tongues by an eastward-extending tongue of the Demopolis member of the Selma chalk. The lower tongue of the Cusseta sand occupies a belt of outcrop about 4 miles wide extending almost due west nearly to the Lowndes County line, where it merges imperceptibly into the lower part of the Demopolis member. Downing and Sprague are near the northern side of this tongue and Ada on the Atlantic Coast Line (Luverne Branch) is just south of the tongue. The upper tongue crops out in a sinuous belt south of the Demopolis member from the southeastern part of T. 13 N., R. 19 E., westward through Sellers to about the vicinity of Mount Carmel, where it merges into the upper part of the Demopolis.

Cooke (97) has mapped the Cusseta sand toward the northeast in Georgia to the Ocmulgee River Valley in Houston County, beyond which it is concealed by an overlap of Tertiary rocks.

Lithologic character.—The lower part of the Cusseta sand in the up-dip exposures on the Enon cuesta consists of coarse sand and fine gravel, but in the down-dip exposures near the Chattahoochee River in Barbour County the lower part consists of finer sand containing water-worn phosphatic pebbles. This coarser basal material is overlain by finer sands. About 50 feet below the top of the formation is a thin bed of calcareous sand, traceable at least as far as the Chattahoochee River, that represents the upper part of the higher tongue of the Demopolis member of the Selma chalk.

As I have examined few exposures along the Chattahoochee River, the part of Langdon's section that is believed to constitute the Cusseta sand is given here. It is difficult to be sure of the exact boundaries of the formation solely from a written account, but apparently the Cusseta is included in beds 17 to 24, referred by Langdon to the Ripley group.

Part of Langdon's description of strata exposed on the Chattahoochee River (50, p. 441) including beds of supposed Cusseta age

		Feet
24.	Soft, less coherent sand, gray in color; appears at the mouth of Cowikee Creek, Alabama, from which the southern bank of the creek, composed of this stratum, may be seen to rise 50 feet from the water	60
23.	About the same in general character as 21, but contains indurated ledges about a foot thick, which show the dip to average 40 feet to the mile, with numerous rolls; ends just above the mouth of Cowikee Creek, Alabama	170
22.	Gray fossiliferous marl, shells much decomposed. An occasional lignitized log and numerous slightly phosphatic nodular masses containing fossils occur in this stratum	5
21.	Gray, glauconitic, and calcareous sand, weathering into fucoidal masses and containing a few soft white phosphatic nodules	10
20.	Fossiliferous marl, about the same in general character as 17, only little or no lignite was seen, the marl appearing to be somewhat glauconitic. (The strata from 17 to 21, inclusive, form a bluff on the eastern bank five miles below Florence, Georgia)	2
19.	Cross-bedded gray sands and clay	15
18.	Sandy stratum, indurated and containing *Ostrea*, sp.	1
17.	Gray, highly fossiliferous marl. The fossils are nearly, if not quite, all bivalves, and are mostly comminuted as if they formed an ancient shore line. There are numerous shark teeth and a hard black substance resembling in sections the under shell of a turtle, black coprolitic (?) pebbles, and fragments of lignite	3
		266

Stephenson (65, pp. 157-159) describes beds of the upper part of the Blufftown formation and the lower part of the Cusseta sand at Woolridge Landing, in sec. 18, T. 12 N., R. 30 E., Barbour County, but assigns the entire Upper Cretaceous section there to his Ripley formation. Apparently bed 1 (3 feet) is sand of the Blufftown formation and the overlying material (beds 2 to 4) is Cusseta sand. Conspicuous among the fossils from his bed 2 are *Trigonarca maconensis, Ostrea pratti,* and a very large undescribed species of oyster that is as long in some specimens as 17.5 inches. This bed is probably the same as Langdon's beds 17 and 18. These basal beds of the Cusseta sand are also well exposed at Roods Lower Bend, 1 mile below Woolridge Landing (65, p. 159), but there the upper part of the Blufftown formation is apparently below water level.

The base of the Cusseta sand is also well exposed in the banks of Little Barbour Creek below the bridge of the River Road, at the northeast corner sec. 2, T. 12 N., R. 29 E., and in the right bank of the Middle Fork of Cowikee Creek just above the bridge of the old Seale-Eufaula highway in the NW¼ NE¼ sec. 18, T. 12 N., R. 29 E., Barbour County, where 5 feet of very fossiliferous sandy clay assigned to the Blufftown formation is exposed at water level, overlain disconformably by thin-bedded sand and clay of the Cusseta sand. In the basal conglomerate of the Cusseta at this locality are many smoothly water-worn small pebbles of sandstone and possibly of phosphate, and specimens of *Trigonia* sp. (large), *Ostrea pratti,* and the large undescribed species of oyster found also at Woolridge Landing and Roods Lower Bend.

Up the dip from these exposures the base of the Cusseta sand is represented by the deposit of coarse sand and fine gravel already described at two places on the face of the Enon cuesta in Bullock County (see Blufftown formation, Lithologic character). The more certainly marine deposits of the Cusseta were observed at the southwest edge of Union Springs on Alabama Highway 6, in the SE¼ sec. 3, T. 13 N., R. 23 E.

Section in cut of Alabama Highway 6, SE¼ sec. 3, T. 13 N., R. 23 E., Bullock County

	Feet
Cusseta sand:	
Gray and brown clayey, micaceous fine sand containing scattered prints of pelecypods; merges upward into red sandy soil; to top of hill at top of cut on old portion of road	45.0
Hard micaceous, calcareous sandstone; ledge not continuous and may be of concretionary origin	1.5
Material similar to top bed	4.5
Calcareous fine-grained sandstone containing waterworn phosphatic pebbles, radiating crystals of calcite similar to those seen in the bank of the Middle Fork of Cowikee Creek in Barbour County, shark teeth, and *Ostrea pratti;* The sandstone was seen only as fragments in the ditch; in the cut it consists of more highly weathered gray fine sand containing phosphatic pebbles and oysters	2.5
Disconformity.	
Blufftown formation:	
Irregularly bedded white micaceous sand containing dark gray clay beds up to 3 inches thick; sand contains well-preserved prints of pelecypods and tubes that resemble *Halymenites major* but are much smaller than usual; to foot of cut	25.0
	78.5

Seventeen feet below the base of the exposure just described there is a hard layer of sandstone filled with internal and external molds of fossils. This sandstone caps a small hill half way down the slope. It may be the same bed as that observed just north of Union Springs and on Spann Hill (see Lithologic character, Blufftown formation) from 30 to 40 feet below the Cusseta-Blufftown contact. This sandstone bed may be an eastern representative of the Arcola limestone member of the Selma chalk.

The lowest part of the Cusseta sand is more chalky in the western part of Bullock County, and near the Montgomery County line it merges into an eastward-extending tongue of marl that constitutes the basal part of the Demopolis member of the Selma chalk. At the base of this tongue of marl is a layer of phosphatic molds of fossils that is described in the section on the lithologic character of that formation. This bed of phosphate is almost certainly the same as that at the base of the Cusseta sand.

The lower part of the Cusseta sand contains a thin bed of bentonite in the western part of Bullock County. The bed was

seen only in a cut of Alabama Highway 6 in the SW¼ NE¼ sec. 6, T. 13 N., R. 21 E. The deposit as it appears in outcrop is too thin to be of commercial value, but if prospecting were done nearby with an auger perhaps a thicker bed would be revealed. The deposit is of especial interest because it occupies about the same stratigraphic position as a deposit in the Coffee sand near Booneville, Mississippi. No bentonite has been found thus far between these two deposits, but they may represent the same ash fall. In the cut the bed of bentonite is only 9 inches thick and overlies about 4 feet of gray sandy clay. An overburden of gray and brown calcareous, finely sandy clay is 11 feet thick.

In the south-central part of Montgomery County the Cusseta sand is divided into two westward-extending tongues of sand by an eastward-extending tongue of marl that represents the middle part of the Demopolis member of the Selma chalk. The two tongues of Cusseta sand maintain their identity nearly as far west as the Lowndes County line, near which they merge by imperceptible gradation into marly deposits classed with the Demopolis.

The lower of these two tongues consists of more or less calcareous, slightly glauconitic, clayey fine sand. If a type locality should ever be required for the tongue, an exposure a mile west of Sprague in the NW¼ SW¼ sec. 5, T. 13 N., R. 18 E., Montgomery County, would be entirely suitable. There 30 feet of massive gray slightly micaceous, very finely and sparingly glauconitic, clayey very fine sand is exposed. A similar section 2¼ miles to the northwest on the northward-facing slope of a small hill in the NE¼ SE¼ sec. 25, T. 14 N., R. 17 E., Montgomery County, is somewhat less weathered.

Section in a road cut in sec. 25, *T.* 14 *N., R.* 17 *E., Montgomery County*

	Feet
Cusseta sand (lower tongue):	
Light-tan very slightly clayey, slightly glauconitic fine sand	20
Soft calcareous sandstone containing *Ostrea plumosa*	4
Concealed to floodplain of branch	5
	29

The top of this tongue of Cusseta sand grades upward into the overlying tongue of marl belonging to the Demopolis member as can be seen in cuts on the Ada road from three-quarters to one and a quarter miles east of Fleta in the NW¼ sec. 14, T. 13 N., R. 17 E., where chalky marl is exposed on the upland, underlain by sandy

chalk, which in turn is underlain just west of the large branch of Pintlalla Creek by chalky sand. Toward the east sand is present rather than chalky marl at successively higher stratigraphic positions until in the hills about 4 miles west-northwest of Pine Level the entire chalk tongue is represented by noncalcareous or slightly calcareous sand except the uppermost part, which persists as chalky sand for more than 50 miles to the east. This narrow unit of calcareous sand is a distinct horizon marker that includes the upper few feet of the *Exogyra ponderosa* zone and the lower part of the *Exogyra costata* and *Exogyra cancellata* zones. The advisability of mapping this unit as a continuation of the tongue of the Demopolis member was considered, but it was decided not to do so because the material is more truly calcareous sand than chalk or marl and because the unit is so thin (about 70 feet thick in west central Bullock County and about 10 feet thick in eastern Barbour County) that its belt of outcrop would have to be exaggerated on the scale of the geologic map (pl. 1) inasmuch as it crops out in the lower slopes of the steep, northward-facing slope of the High Ridge cuesta. In any more detailed surveys of eastern Alabama the unit might very well be given a name and mapped as a member of the Cusseta sand, or might be considered a sandy facies of the upper tongue of the Demopolis member. In the western part of Montgomery County the equivalent beds of the Demopolis member crop out in road-side ditches 1½ miles north of Mount Carmel on the Fleta road in the SE¼ NE¼ sec. 28, T. 13 N., R. 17 E., where the chalky marl contains an irregular variety of *Exogyra cancellata* characterized by a prominent umbonal ridge. The chalky sand in the Cusseta was observed in eastern Montgomery County in roadside ditches in the SW¼ SE¼ sec. 14, SE¼ NW¼ sec. 24, and in the NW¼ SE¼ sec. 25, T. 13 N., R. 19 E., and in a series of road cuts near the center of sec. 24, T. 13 N., R. 20 E., which is the westernmost point at which a characteristic bed of phosphatic molds of mollusks was observed in the Cusseta.

Section in road cut, SW¼ SE¼ sec. 24, T. 13 N., R. 20 E., Montgomery County

	Feet
Cusseta sand:	
Brown calcareous, sandy clay containing *Exogyra cancellata* (var. with strong umbonal ridge), *Anomia argentaria*, and phosphatic molds of fossils; lower part contains abundant *Gryphaea* sp.	15
Hard ferruginous sandstone containing abundant molds of *Cardium* sp.	1
Calcareous, sandy clay containing *Exogyra ponderosa*	4
	20

In Bullock County one of the best exposures of this member of the Cusseta sand is in a series of road cuts on the road from Hector to High Ridge in the N½ sec. 25, T. 13 N., R. 21 E. The northern exposure consists of about 12 feet of very calcareous, clayey, glauconitic sand containing well-rounded phosphatic bone fragments, *Exogyra ponderosa, Ostrea plumosa, O. falcata, Anomia argentaria, Gryphaea mutabilis,* and abundant shark teeth. This bone bed is traceable for several miles toward the east at the same stratigraphic horizon. A quarter of a mile farther south and 40 feet higher (aneroid) the following section is exposed in the SW¼ NE¼ sec. 25, T. 13 N., R. 21 E.

Section on northward-facing slope of High Ridge, Bullock County

	Feet
Red and gray coarsely micaceous fine to coarse sand (slumped from the Ripley formation exposed higher on the hill)	8
Cusseta sand:	
Gray and brown micaceous, clayey, calcareous fine sand containing *Exogyra cancellata* (var. with umbonal ridge)	11
More or less calcareous, clayey fine sand containing in upper part many *Ostrea plumosa, O. falcata, O. mesenterica,* and *Exogyra cancellata* (var. with umbonal ridge); basal 4 feet made up largely of *Gryphaea mutabilis,* abundant phosphatic molds of mollusks, and a few water-worn ferruginous sandstone cobbles and water-worn shells	29
Disconformity (local?).	
Cusseta sand:	
Compact calcareous sandstone containing abundant *Pecten* (*Neithea*) sp., *Ostrea* aff. *O. subspatulata, O. tecticosta, O. falcata, Exogyra costata, Cardium* sp. (molds), *Paranomia scabra,* and water-worn specimens of *Exogyra ponderosa;* this layer consists of several hard beds of sandstone separated by softer sand; lowest bed exposed is hard sandy limestone containing abundant shells and molds of *Cardium* sp.	12
	60

The top of High Ridge ¼ mile south is 50 feet (aneroid) above top of the section described above. The contact of the Cusseta sand and the overlying Ripley formation is not well exposed, and it is possible that the material at the top of the described part of the section may not have slumped more than 10 or 15 feet.

The bone bed or the higher phosphatic mold bed or both were seen on every road east as far as the road from Union Springs to Jenkins Crossroads near the southeast corner sec. 7, T. 12 N., R.

23 E., where Chunnennuggee Ridge makes its sharp bend to the north changing its position from the High Ridge to the Enon cuesta. These two beds were not recognized farther east in Bullock County, but the member of calcareous clay and sand continues eastward across the county, cropping out in sec. 3, T. 12 N., R. 24 E., on the Aberfoil road 1¼ miles north by west of Ox Level.

In Barbour County the calcareous member was recognized 3 miles east-northeast of Mount Andrew on the Comer road in the NE¼ sec. 36, T. 12 N., R. 25 E., and on the Comer-Clayton road at the north edge of sec. 8, T. 11 N., R. 26 E., where the Providence sand has, apparently, overlapped all of the Ripley formation and the upper part of the Cusseta sand and rests on this calcareous sand member of the Cusseta.

Section in road cut in sec. 8, T. 11 N., R. 26 E., Barbour County

	Feet
Providence sand:	
Soft sandstone containing *Exogyra costata, Cardium* sp., *Crassatella* sp., *Turritella* sp., and *Volutoderma* sp.	1
Finely sandy chalky clay containing a few phosphatic molds of mollusks	5
Sandy limestone containing large phosphatic pebbles	1
Unconformity (overlap).	
Cusseta sand:	
Chalky fine sand	3
	10

Half a mile south by east along the road and 60 feet above the top of this exposure is a contact of coarse sand and fine gravel resting on finely micaceous sand, all believed to be Providence sand; on higher parts of the hill are coarse sand, gravel and kaolin-like clay characteristic of the Providence sand. The geologic relations in this region southeast of Mount Andrew are not entirely clear after our hasty reconnaissance, but it is believed that none of the material seen along this road can be assigned to the Ripley formation.

Six miles farther east deposits of the Ripley formation are exposed on the Batesville-White Oak Springs road overlying the Cusseta sand. The calcareous sand member of the Cusseta is exposed near the center of sec. 27, T. 12 N., R. 27 E., where approximately 5 feet of greenish-gray micaceous clayey sand, in part

indurated into soft sandstone, contains *Exogyra costata, Cardium* sp., *Anomia argentaria, Paranomia scabra, Ostrea falcata, Gryphaea* sp., *Baculites* sp., and *Hamulus onyx.* The same bed is exposed on this road 2 miles south by west and 65 feet lower, just west of a headwater branch of Barbour Creek in the NE¼ SE¼ sec. 4, T. 11 N., R. 27 E., in a section that resembles the exposures on the Hector-High Ridge road in Bullock County.

Section on White Oak Springs road, 3¼ miles (airline) south by west of Batesville, Barbour County

	Feet
Cusseta sand:	
Gray sandy clay, calcareous in lower part; phosphatic molds in basal foot; *Exogyra costata, Gryphaea mutabilis, Paranomia scabra,* and other common fossils	11
Chalky, clayey coarse sand	2
Red and gray clayey coarse sand	10
	23

Sandstone characteristic of the Ripley formation is exposed three-quarters of a mile southwest of, and about 50 feet higher than the preceding locality, but the contact between the Cusseta and the Ripley was not seen.

The easternmost point in Alabama at which this calcareous member of the Cusseta sand was seen is on the Spring Hill road (Comer Memorial Highway) 2 miles north of Lugo in the NE¼ SE¼ sec. 27, T. 12 N., R. 28 E., where very chalky, clayey fine sand is exposed in the roadside ditch and contains *Exogyra cancellata. Graphaea mutabilis,* and *Paranomia scabra.* This exposure is noteworthy in that it is the only place from which *Exogyra cancellata* has been collected in Barbour County, to the best of my knowledge. The basal gravel of the Ripley formation crops out on this road three-quarters of a mile toward the south and at an altitude 10 feet higher than this exposure.

The upper part of the Cusseta sand consists of fine to very fine micaceous sand that is generally not very fossiliferous. This part of the formation has been described in the section on the High Ridge-Hector road, Bullock County. The contact with the overlying Ripley formation is well-exposed in a cut about a hundred feet south of an east-west road, 2½ miles east-southeast of Ox Level in the NW¼ NE¼ sec. 24, T. 12 N., R. 24 E., Bullock County on the Smut Eye road.

Section in road cut 2½ miles east-southeast of Ox Level, Bullock County

	Feet
Ripley formation:	
Leached light-gray sand	5
Coarse and fine sand and fine gravel; contains at base many stringers of quartz pebbles ranging up to one-half inch in diameter	5
Disconformity.	
Cusseta sand:	
Yellow and pink clayey, micaceous fine to medium sand (weathered portion of underlying bed)	7
Dark-gray slightly clayey fine to medium-grained sand containing large mica flakes; no fossils	4
	21

This unfossiliferous dark-gray to dark blue-gray sand is characteristic of the upper part of the Cusseta sand in eastern Bullock County.

The westernmost exposure that might be referred to the upper part of the Cusseta sand is on the Fleta road about half a mile north of Mount Carmel in the SE¼ NE¼ sec. 33, T. 13 N., R. 17 E., Montgomery County, where 8 feet of tan, gray, and brown micaceous, finely sandy clay contains fragments of *Exogyra cancellata, Anomia tellinoides,* and *Ostrea plumosa.* Much coarser sand that is believed to represent the lower part of the Ripley formation is exposed at Mount Carmel.

Thickness.—The only measured thickness of the Cusseta sand is that of Langdon (50, p. 441) whose descriptions indicate a thickness of about 266 feet on the Chattahoochee River. This thickness agrees reasonably well with estimates made from dip and barometer observations in the western part of Barbour County. South of Union Springs in Bullock County the formation appears to be somewhat thinner, but in the western part of Bullock County the formation is apparently considerably thicker. No estimates can be made of the thickness of the formation in Montgomery County, but it appears to approach that of the Demopolis member of the Selma chalk, which is probably 450 feet or more.

Stratigraphic relations.—The Cusseta sand rests disconformably on the Blufftown formation from the Chattahoochee River westward to the vicinity of Union Springs, Bullock County. In the

western half of Bullock County it rests disconformably on the Arcola limestone member of the Selma chalk, but near the Bullock-Montgomery County line the basal part of the Cusseta merges laterally into an eastward-extending tongue of the basal part of the Demopolis member of the Selma chalk and westward across Montgomery County the Cusseta rests conformably on this tongue of the Demopolis nearly to the Lowndes County line where the lower part of the Cusseta merges laterally into the lower part of the Demopolis member of the Selma.

In the central part of Montgomery County the Cusseta sand is split into two westward-extending tongues by an eastward-extending tongue of the Demopolis member. The lower of these tongues gradually merges into the tongue of the Demopolis member toward the west, successively lower parts of the Cusseta passing laterally into chalky marl, and as explained above the entire tongue merges into chalk of the Demopolis member near the Montgomery-Lowndes County line. The upper tongue of the Cusseta sand extends westward through Montgomery County becoming more chalky toward the west until near the Lowndes County line it, too, merges into chalky marl.

In Barbour County the Cusseta sand is overlain disconformably by the Ripley formation except in the area east of Mount Andrew, where it appears to be overlain by the overlapping Providence sand. The disconformity between the Cusseta and the Ripley probably represents very little geologic time and is probably the physical expression of a transgression of the Ripley sea, for it could not be found in the western part of Montgomery County. Futhermore the Ripley appears to rest on the Demopolis member of the Selma chalk with no evidence of a break in deposition.

The Cusseta sand includes parts of the two great faunal zones of the Upper Cretaceous of the Coastal Plain. The lower two thirds of the formation is within the *Exogyra ponderosa* zone, about the upper half of which is included in the formation. The upper third of the formation contains the lower half of the *Exogyra cancellata* zone, which constitutes the lower part of the *Exogyra costata* zone.

The Cusseta sand is the exact time equivalent of the Demopolis member of the Selma chalk and the correlations of that unit with formations in other States and with the European stages apply equally well to the Cusseta sand, and are not repeated here.

Physiographic expression.—The Cusseta sand forms the bedrock in the middle part of the Chunnennuggee Hills physiographic district as far west as Union Springs, and is at the northern side of the district in western Bullock and Montgomery Counties.

The part of the Chunnennuggee Ridge of earlier writers that corresponds to the northern edge of the Cusseta sand is here called the Enon cuesta scarp. The Enon cuesta is characterized by a steep northward-facing scarp nearly 200 feet high between Union Springs and Enon, Bullock County, and a long gentle back slope to the south from the top of this scarp. The scarp is best developed between Union Springs and Enon, but can be traced to the west as a series of low hills that are in contrast with the prairie to the north. Near Enon the drainage of tributaries of the Middle Fork of Cowikee Creek has cut back into the hills in such a fashion that the scarp bends due south about 4 miles. It bends east again along the northern side of Spring Hill to the valley of the Middle Fork of Cowikee Creek, which cuts through the cuesta. From this fork the cuesta scarp trends northeast following the strike of the Cusseta sand through Russell County by way of Glenville. The scarp is very irregular in Russell County because it is transected by the North Fork of Cowikee Creek and Hatchechubbee Creek. The remnants of the scarp in Russell County, however, are prominent features of the landscape especially at Glenville and east of Pittsview.

The back slope of the cuesta is nearly a true dip slope on the coarse sand and fine gravel that form the basal part of the Cusseta sand. The dip slope is well shown south of Peachburg, Bullock County, and except for dissection by the branches of the Middle Fork of Cowikee Creek, it is almost perfectly developed on the road from Enon to Midway, along which each hill is covered by Cusseta sand and each valley is cut into the Blufftown formation.

The sands of the middle and upper parts of the Cusseta sand give rise to gently rolling hills on the back slope of the cuesta, but these are so much smaller than the main cuesta scarps of the Enon cuesta (Cusseta) and the High Ridge cuesta (Ripley) that they are scarcely noticed by the traveller.

The upper part of the Cusseta sand crops out in the lower slopes of the High Ridge cuesta that owes its existence to the resistance of the basal beds of the Ripley formation. These upper Cusseta beds, therefore, have little effect on the topography.

The lower tongue of the Cusseta sand in Montgomery County gives rise to a belt of rolling hills that presents a striking contrast to the more subdued topography of the Black Prairie belt to the north and the rolling prairie of the upper tongue of the Demopolis to the south. Topographic maps may show that this tongue forms a small cuesta, but I did not detect this in travelling through the region with only planimetric maps.

RIPLEY FORMATION

Name.—The name Ripley group was first used by Hilgard (26, pp. 83-95) and was intended to apply to all the strata in Mississippi included between the top of the "Rotten Limestone" (Selma chalk) and the base of the overlying Tertiary deposits. In 1871 Hilgard (31) applied the name to deposits in Alabama of the same age as those in Mississippi. Smith and Johnson (43) accepted Hilgard's name and later with Langdon (50) extended it downward in eastern Alabama to include strata older than any included in the Ripley of Mississippi. In 1914 Stephenson (69, p. 15) showed that the uppermost part of Smith's Ripley is Tertiary and that limestone (chalk) included in the upper part of Smith's Ripley was a part of a long relatively thin mass of chalk extending east from the main body of chalk in Sumter County (69, p. 17). In 1917 Stephenson (71, p. 250) named this chalk the Prairie Bluff tongue of the Selma chalk. In 1937 Stephenson and Monroe (94) showed that this chalk is a part of a widespread formation separate from the Selma proper, and named it the Prairie Bluff chalk.

In 1909 Veatch (62, pp. 86-89) divided the Chattahoochee River section of the Ripley of Smith, Johnson and Langdon (50) into four units: Lower marl (Blufftown), middle unconsolidated sand (Cusseta), upper marl (Renfroes), and upper unconsolidated sand (Providence). In 1911 Stephenson (65, p. 72) accepted Veatch's Cusseta sand and Providence sand as members of the Ripley formation but considered the Blufftown partly of Eutaw age and partly Ripley. The upper part of the Blufftown and the Renfroes marl were treated as typical marine beds of the Ripley formation not needing member names. In 1914 Stephenson (65, p. 19) recognized the Providence sand member of the Ripley in Alabama, but considered all material below to the top of the tongue of Selma chalk in Russell County as undifferentiated Ripley. This classifi-

cation was still accepted in his discussion of the Mesozoic in the Geology of Alabama (77, pp. 240-245) published in 1926, except that he recognized that the so-called Eutaw of the Chattahoochee River region included strata younger than any of the Eutaw farther west.

In 1938, Stephenson and Monroe (96, pp. 1648-1652) reconsidered the classification of the Ripley in eastern Alabama and Georgia and divided the section of rocks on the basis of stratigraphic breaks in deposition, lithologic character, and faunal content. In this paper the Ripley was restricted to the sequence of rocks included within the *Exogyra costata* zone, but not including the Providence sand. Underlying the Ripley is the Cusseta sand, equal to the old Cusseta sand member of the Ripley formation but also including marine deposits of Cusseta age that formerly had been called undifferentiated Ripley. The marine beds underlying the Cusseta that formerly were treated as an undifferentiated part of the Ripley were now included in the Blufftown formation. The Providence sand member of the Ripley was shown to be the age equivalent of the Prairie Bluff chalk and to be separated from the underlying typical Ripley by an unconformity. The Providence sand was, therefore, set up as a separate formation.

In the present paper the limits of the Ripley formation differ from those proposed in 1938 (96) in that the base of the formation in eastern Alabama is placed at the base of a thick deposit of coarse sand and fine gravel rather than at the contact of the *Exogyra ponderosa* and *Exogyra costata* zones. This further restricts the Ripley by about 50 feet or less, but the gravel bed rather than the faunal zone contact seems a more logical base for the formation. This proposed restriction of the Ripley has the additional advantage that the base of the Ripley is at very nearly the same stratigraphic position from the Chattahoochee River to Sumter County.

No type locality for the Ripley was designated by Hilgard, but sand, clay, and limestone underlying the Owl Creek formation in Tippah, Union, and Pontotoc Counties, Mississippi, may be regarded as typical of the formation.

Areal extent.—The Ripley formation enters Alabama from Mississippi in a narrow belt less than 2 miles wide in the northern part of Sumter County. It extends southeast maintaining about the same width, except where it is involved in the faulting of the

Livingston fault zone, to the eastern part of the county where the belt becomes considerably wider, probably because of slightly less overlap by the overlying Prairie Bluff chalk. In central Marengo County the belt attains a width of nearly 8 miles because of a dip slope from Old Spring Hill toward the south to Chickasaw Bogue. The belt extends east-southeast and east with minor variations in width, mostly caused by varying topography, through Wilcox, Dallas, Lowndes, Montgomery, Pike, and Bullock Counties to the western part of Barbour County, where the entire Ripley formation is apparently overlapped by the Providence sand. In the middle of Barbour County the Ripley reappears from beneath the Providence and the belt of outcrop continues in a northeasterly direction to the valley of the Chattahoochee River. The width of outcrop on the river is very wide, partly because the river does not flow parallel to the dip. Furthermore the northern boundary of the formation may not be drawn correctly, as exposures along the river have not been studied.

Lithologic character.—In western Alabama the Ripley formation consists of very calcareous micaceous sand and sandstone that is about midway in composition between sand and chalk. This material was formerly called (96, p. 1650) an upper sandy facies of the Selma chalk, but in the early work of Stephenson (69, pp. 21-22) it was recognized to be the exact equivalent of the Ripley of Mississippi and the upper part of the Ripley of Alabama. Consequently in the present report it has been called Ripley formation (chalky facies). Toward the east in Alabama this calcareous sand merges laterally into sand and clay to which the name Ripley has been applied since 1871 (31). East of Montgomery the lower part of the Ripley formation consists of coarse sand and fine gravel, formerly considered Lafayette.

In the western part of Sumter County there are many exposures of the Ripley formation (chalky facies), but most of these are in fault blocks and the entire thickness has not been seen at any one place. The sections in Sumter County about to be described are in the Epes quadrangle, parts of which have been studied in considerable detail.

The Ripley formation (chalky facies) is well exposed in a deep cut on the east side of U. S. Highway 11 in the SW¼ SW¼ SW¼ sec. 35, T. 20 N., R. 2 W. Three small reverse faults cut this

exposure; the two to the south have displacements of only about a foot and do not reach the top of the exposure as they affect only the strata below bed 8 in the accompanying description. The fault at the northern end of the cut has a displacement of 4 feet and affects all the beds in the exposure. The faults all have a strike of about N. 60° W., and dip about 45° N. 30° E. The strata between the faults dip about 8° NE. The section described is the part of the exposure just south of the northernmost fault.

Section on U. S. Highway 11, *sec.* 35, *T.* 20 *N., R.* 2 *W., Sumter County*

		Feet
Ripley formation (chalky facies):		
16.	Light reddish-brown fine sandy loam (weathered from chalky facies)	2.0
15.	Compact calcareous, finely micaceous fine-grained sandstone, containing impressions of fossils	1.0
14.	Light-tan micaceous, chalky fine soft sand containing borings and fossil shells including *Exogyra costata, Gryphaea mutabilis, Ostrea falcata, Anomia argentaria, Paranomia scabra,* and *Crenella serica* (the same fossils are found in the beds below, but the names are not repeated); contains many balls of soft limonite that are the weathered remains of balls of iron pyrites, probably marcasite	3.0
13.	Similar to overlying layer but more compact	1.5
12.	Tan chalky, micaceous sand like bed 14; borings have walls of dark-gray clayey silt	2.7
11.	Compact light-gray chalky, micaceous soft fine-grained sandstone	1.3
10.	Tan chalky, micaceous fine sand containing streaks and tubes of gray clayey silt and small irregular lenses of light reddish-brown sand	1.5
9.	Medium-gray chalky, micaceous very fine sand; slightly indurated at top	2.0
8.	Light-gray very hard chalky, micaceous sandstone; most resistant layer in the cut. This layer is offset only at the fault near the north end of the cut where the displacement amounts to 2 feet	1.5
7.	Compact dark-gray chalky, micaceous fine to very fine sand	4.0
6.	Indurated lighter-gray chalky fine to very fine sand	2.0
5.	Sand similar to bed 7	1.5
4.	Light-gray chalky, micaceous sandstone	1.0
3.	Compact light-gray chalky, micaceous sand	2.5
2.	Light-gray chalky, micaceous sandstone	1.0
1.	Compact light-gray chalky, micaceous sand; at north end of cut, north of the main fault, 7 feet of this bed is exposed	4.5
		33.0

Fig. 11.—Ripley formation (chalky facies) thrust over Prairie Bluff chalk by a reverse fault. Cut of the Alabama Great Southern Railway at the southeast corner of sec. 10, T. 19 N., R. 2 W., Sumter County.

The contact of the Ripley formation (chalky facies) and the overlying Prairie Bluff chalk is well exposed in the central part of a cut of the Alabama Great Southern Railway at a bend in the track in the SW¼ SW¼ SW¼ Sec. 11, T. 19 N., R. 2 W., Sumter County. In the northern third of the cut is a reverse fault (fig. 11) that has a strike of about N. 50° W., and dips about 43° SW. North of the fault the cut consists entirely of Prairie Bluff chalk. The fault plane is characterized here, as elsewhere in the Livingston fault zone, by a layer of gouge some 3 to 6 inches wide consisting of laminae of sand and chalk resembling flow structure of igneous rocks.

Section in central part of cut of Alabama Great Southern Railway, Sec. 11, T. 19 N., R. 2 W., Sumter County

	Feet
Prairie Bluff chalk:	
Massive coarsely sandy chalk	15
Bedded softer coarsely sandy chalk; many pebbles of underlying sandy chalk reworked in basal foot; a few phosphatic molds	8
Disconformity.	
Ripley formation (chalky facies):	
Finely sandy, micaceous compact chalk containing in upper part borings filled with coarsely sandy Prairie Bluff chalk	1.5
More compact white finely sandy chalk, nearly a limestone	0.5
Soft thick-bedded sandy, micaceous chalk	4.5
	29.5

The lower part of the Ripley formation in eastern Sumter County where it is beginning to merge laterally into the chalky facies is well exposed on a cut on the northwestward-facing slope of the Epes-Brewersville road in the S½ sec. 6, T. 19 N., R. 1 W. Very clayey chalk containing *Exogyra cancellata* was observed in gullies northeast of the road 22 feet below the base of the section here described.

Section on Epes-Brewersville Road, Sumter County

	Feet
Ripley formation:	
Reddish-brown micaceous, clayey fine sand grading downward into tan and gray micaceous, slightly glauconitic fine to very fine sand	26.0
Light grayish-tan very finely micaceous, fossiliferous calcareous sandstone	1.0
Tan slightly glauconitic, slightly chloritic, calcareous, micaceous very fine sand containing tubes of dark-gray clayey silt; in places contains slightly indurated fossiliferous chalky beds	22.0
Dark-gray to light blue-gray soft sandstone	1.5
Dark-gray, weathering to tan, slightly glauconitic, micaceous, chalky, clayey sand	5.5
Dark-gray, weathering to tan, chalky, micaceous fine sand containing abundant *Gryphaea mutabilis;* slightly indurated layer at top; 3 slightly indurated layers at base	14.0
Dark-gray (light blue-gray where dry) glauconitic, micaceous, chalky very fine sand; slightly indurated in some beds	11.0
	81.0

In the eastern part of the Epes quadrangle the chalk near the middle of the *Exogyra cancellata* zone of the Demopolis member of the Selma chalk is sandy in contrast to the same beds farther west that contain little if any sand. This sandy chalk is exposed in a ditch on the Brewersville road 2¼ miles south (airline) of Epes in the NE¼ NW¼ sec. 6, T. 19 N., R. 1 W., and at the foot of a southwestward-facing slope on the old Brewersville-Belmont road in the SW¼ SW¼ sec. 12, T. 18 N., R. 1 W., both in Sumter County. At both places the sandy chalk is overlain by clayey chalk. These two exposures are the western end of a tongue of the Ripley formation that extends westward into the Demopolis member. On the Tombigbee River the sandy chalk is represented by sand and the overlying chalk has merged eastward into sand, both becoming integral parts of the Ripley formation. Stratigraphically, then, the base of the Ripley formation is constant throughout most of Mississippi and the western part of Sumter County just above the top of the *Exogyra cancellata* zone, but from the eastern part of Sumter County to the Chattahoochee River the base of the Ripley formation is at a lower stratigraphic position near the middle of the *Exogyra cancellata* zone.

On the Tombigbee River the Ripley formation is well exposed in bluffs on both sides of the river from 1 to 5 miles above Moscow Landing (Rooster Bridge) in sec. 19, T. 17 N., R. 1 E., but between Ellis Landing (sec. 15, T. 17 N., R. 1 E.) and Paces Landing (sec. 2, T. 17 N., R. 1 E.) the strata are displaced by numerous reverse faults that are probably the eastern extension of the fault zone, so well developed north of Livingston. The contact of the Ripley and the Demopolis member of the Selma chalk is well shown in several of the raised fault blocks (fig. 12). The southwesternmost exposure of the Demopolis chalk is in a fault block about a mile below Paces Landing in sec. 11, T. 17 N., R. 1 E., where the following section is exposed:

Section in a raised fault block on Tombigbee River, Marengo County

	Feet
Ripley formation:	
Gray sandy, micaceous, chalky clay containing somewhat harder more chalky layers; *Exogyra cancellata, Anomia tellinoides, A. argentaria, Ostrea plumosa, O. falcata,* and *Gryphaea mutabilis*	22
Hard layer of chalk	1
Soft sandy clay like above	4
Selma chalk (Demopolis member):	
Interstratified hard chalk and soft clayey chalk; same fauna as Ripley formation	9
Hard compact chalk containing a few thin softer layers; to water level of Tombigbee River	17
	53

Fig. 12.—Contact of the Selma chalk and the overlying Ripley formation in a small block bounded by reverse faults. Left bank of the Tombigbee River in sec. 11, T. 17 N., R. 1 E., Marengo County.

Throughout much of the region between the Alabama and Tombigbee Rivers the Ripley formation is overlain directly by the Clayton formation or the Sucarnoochee clay (Paleocene), which overlap and cut out the intermediate Prairie Bluff chalk. On U. S. Highway 43 just north of Linden on the northeastward-facing slope of Chickasaw Bogue Valley, in the NW¼ SW¼ sec. 28, T. 16 N., R. 3 E., Marengo County, highly cross-bedded white micaceous sand of the Ripley formation is overlain unconformably by featureless brown clayey sand of the Midway group. Half a mile west of Linden on the Jefferson road in the NE¼ SW¼ sec. 32, T. 16 N., R. 3 E., 4 feet of coarsely sandy chalk of the Prairie Bluff chalk is overlain unconformably by coarse sand of the Midway group into which have been reworked abundant phosphatic molds derived from the Prairie Bluff. The disconformity at this place is exceptionally irregular, the erosion channels in the Prairie Bluff chalk reaching a depth of 3 feet. The contact of the Prairie Bluff chalk and the Ripley formation was not observed here but it is probably concealed beneath the soil a short distance down the hill to the west.

In a road cut in the NW¼ NE¼ sec. 18, T. 15 N., R. 5 E., Marengo County, only 9½ feet of Prairie Bluff chalk is exposed between the Clayton formation (Midway group) and the Ripley formation.

Section half a mile northeast of Thomaston, Marengo County

	Feet
Clayton formation:	
Light-brown micaceous sand; bottom 2½ feet contains several layers of leached phosphatic molds reworked from the underlying rock	16.0
Disconformity.	
Prairie Bluff chalk:	
Hard sandy limestone containing *Exogyra costata* and phosphatic molds	9.5
Disconformity.	
Ripley formation:	
Soft light-brown micaceous, glauconitic sand	4.5
Very hard, tightly cemented calcareous sandstone; (Concealed below, but is probably loose sand)	1.0
	31.0

In this region the part of the Ripley formation within the *Exogyra cancellata* zone is well exposed in the ditch at the side of the old Dayton road (a few hundred feet east of the new road) 3¼ miles north of Thomaston, in the SE¼ NE¼ sec. 36, T. 16 N., R. 4 E., Marengo County, where a very hard layer of calcareous sandstone in the bottom of the ditch is overlain by 6 feet of tan glauconitic fine sand containing *Exogyra cancellata, Pecten* (*Neithea*) sp. (a species of *Neithea* believed by Dr. Stephenson to be confined to the *Exogyra cancellata* zone), and *Paranomia scabra,* which in turn is overlain by a 1-foot layer of soft glauconitic fine-grained sandstone.

A common type of material in the Ripley formation is highly micaceous pink very fine sand. This is well shown in a deep cut on a secondary road just south of U. S. Highway 43 at the south edge of Old Spring Hill, Marengo County. East of the Alabama River in Dallas County, although most of the belt of outcrop of the Ripley formation is concealed by high level terrace deposits of the Alabama River, similar material is exposed near the base of the Ripley formation at the top of a high hill on Alabama Highway 43 in the NW¼ sec. 27, T. 14 N., R. 10 E., where the following section is exposed (thicknesses are estimated):

Section in deep cut of Alabama Highway 43, *sec.* 27, *T.* 14 *N., R.* 10 *E., Dallas County*

	Feet
Terrace deposit:	
Fine to coarse red sand and gravel	20
Disconformity.	
Ripley formation:	
Pink micaceous fine sand containing thin beds of marly, sandy, micaceous clay	15
Highly micaceous, finely sandy clay, containing *Ostrea subspatulata* and *Anomia argentaria*	20
	55

From Dallas County eastward the top of the Ripley formation is hard sandy limestone at most places. This limestone, overlain by marl of the Prairie Bluff chalk, is exposed on Alabama Highway 43 in the NW¼ sec. 18, T. 13 N., R. 10 E. It forms a small natural bridge over Bear Creek a mile south of Minter in the NE¼ NE¼ sec. 31, T. 13 N., R. 11 E. In Lowndes County it is well exposed just below marl of the Prairie Bluff chalk at several places along

the Mount Willing-Farmersville road, particularly near Braggs in sec. 31, T. 13 N., R. 13 E., south of Mount Willing on the Fort Deposit road in sec. 5, T. 12 N., R. 14 E., on the Letohatchie-Fort Deposit road in the NE¼ sec. 9, T. 12 N., R. 15 E., and on U. S. Highway 31 in a small cut at a negro church and school a mile south-southwest of Sandy Ridge in the NE¼ SW¼ sec. 16, T. 12 N., R. 16 E., where the base of the overlying Prairie Bluff chalk, here a marl, contains well-rounded, reworked blocks of the limestone.

A large outlier of the Ripley formation in Dallas and Lowndes Counties forms the ridge between Mush and Dry Cedar Creeks. The geology of this ridge, on which are located Pleasant Hill and Collirene, has been described accurately by Thornton (21, p. 234) and Langdon (50, pp. 427-428). Langdon described the section as follows:

Section at Collirene, Lowndes County (described by Langdon)

	Feet
1. Pebbles (Lafayette)	15
2. Calcareous sandy conglomerate	5
3. Micaceous sand, bluish gray, unfossiliferous	105

Langdon's "Lafayette" is actually a high-level terrace deposit of the Alabama River, and it can be recognized at approximately the same altitude above the river throughout this area. Langdon describes the chalk that crops out south of Collirene in the valley of Dry Cedar Creek, and correctly assigns it to the Selma (Demopolis member).

In the lower part of the Ripley formation in the eastern part of Lowndes County and the southwestern corner of Montgomery County is a thick deposit of bentonite that may prove of considerable economic value. Mr. Brown and I did not have the time to determine the areal extent of the deposit, but we believe that prospecting may show that it is accessible to the surface over several thousand acres. The exposures that we saw are on U. S. Highway 31 near the center of the NE¼ sec. 3, T. 12 N., R. 16 E., about 2 miles southwest of Devenport, and on the Highland Home road 1.1 miles southeast of Devenport in sec. 31, T. 13 N., R. 17 E.

Section in cuts on U. S. Highway 31 about 2 miles southwest of Devenport, Lowndes County

		Feet
Ripley formation:		
7.	Highly leached light-gray and light dirty-brown sand	4.0
6.	Mottled red and yellow clayey, micaceous fine to medium sand	12.5
5.	Concealed by soil	21.7
4.	Compact light-gray slightly sandy and micaceous, silty claystone breaking with conchoidal fracture (bentonitic)	18.4
3.	Light cream-colored clay (bentonite) breaking with conchoidal fracture; the lower part is badly broken suggesting slumping; basal contact tilted	6.0
2.	Compact dark-gray micaceous, silty, clayey sand	2.5
1.	Concealed by slumped sand and bentonitic clay	12.4
		77.5

C. S. Ross examined samples from this section and reports[a]:

> The best bentonite [of several samples] is from locality No. 7, Lowndes County, bed 3 of section. In this the volcanic ash structure is better retained than in most of the Mississippi bentonites.
>
> No. 4 bed from the same place retains a somewhat poorer ash structure.
>
> No. 1 is a nearly pure montmorillonite but shows no ash structure.

Section in cut on Highland Home road, 1.1 miles southeast of Devenport, Montgomery County

		Feet
Ripley formation:		
4.	Thin-bedded micaceous, clayey fine sand; merging upward into soil	5.0
3.	Finely sandy, micaceous bentonitic clay	3.5
2.	White to cream-colored clay (bentonite)	2.5
1.	Thin-bedded brown and gray clayey, micaceous sand	4.0
		15.0

Dr. Ross also examined a sample from bed 2 in this section and in the same letter reports:

> The specimen from 1.1 miles southwest of Devenport, Montgomery County, contains abundant biotite that is no doubt of volcanic origin, but also quartz and muscovite, and so has probably been somewhat reworked.

[a] Ross, C. S., Letter dated June 22, 1940.

Mr. P. G. Nutting made laboratory tests of the oil-bleaching power of the clays after acid-treatment (for description of test see 99, pp. 13-15) and reports that the samples fom bed 3 in the Lowndes County section and bed 2 in the Montgomery County section are very good fuller's earths. After acid-treatment the bleaching power is slightly below the standards he has set up, but this may be because the samples are from the weathered outcrops. Before the deposits are condemned fresh samples from beds 3 and 4 in the Lowndes County section and bed 2 in the Montgomery County section should be obtained with an auger for further tests.

This bentonite deposit is of interest scientifically because it records the fall of a thick deposit of volcanic ash in Alabama during Ripley time. The deposit is of economic interest because it is the thickest deposit of bentonite thus far found in the Upper Cretaceous rocks of Alabama.

The contact of the Ripley formation and the overlying Prairie Bluff chalk is exposed at several places on the road from Devenport to Highland Home in Crenshaw County. One of the best of these exposures is near the west line of sec. 15, T. 12 N., R. 17 E., Crenshaw County.

Section on Devenport-Highland Home road, Crenshaw County

	Feet
Prairie Bluff chalk:	
Light-gray, weathering to light-brown, calcareous clay; indurated layer of micaceous, sandy clay at base	6
Highly calcareous, highly glauconitic, slightly sandy, chalky clay containing abundant phosphatic molds of fossils including *Liopistha protexta, Idonearca* sp., and other mollusks; glauconite abundant in pockets, predominantly in upper part; shells of *Plicatula urticosa* and *Exogyra costata* abundant; increasingly sandy in lower parts of bed	9
Very compact, tight light-gray sandy chalk containing scattered phosphatic molds of mollusks; 6-inch layer of large water-worn cobbles of sandy limestone at base	4
Disconformity.	
Ripley formation:	
Tan highly micaceous, calcareous, clayey very fine sand; much less compact than overlying chalk	4
	23

As already explained the sand and sandy clay of the Ripley formation rests conformably on the Demopolis member of the Selma chalk from Montgomery County west, the contact being gradational. In the western part of Montgomery County, on the other hand, the basal sand of the Ripley formation is replaced by coarse sand and fine gravel that rests with a sharp contact on a westward-extending tongue of the Cusseta sand. The most westerly point at which I have seen this coarse sand of the Ripley is on the eastward-facing slope of the county-line road a mile and a half west of Sellers. It is well exposed half a mile northwest of Ramer on the Ada road near the crest of a northward-facing scarp in the NE¼ SW¼ sec. 35, T. 13 N., R. 18 E. A road cut north of this cut and 45 feet below the crest of the scarp shows 20 feet of light gray and brown finely sandy and micaceous, slightly calcareous clay that is assigned to the Cusseta sand.

The scarp caused by the basal coarse sand and fine gravel of the Ripley formation is a prominent feature of the topography from Ramer eastward to the central part of Bullock County. It is the northward-facing scarp of the High Ridge cuesta and in this region it constitutes the southern divide of the Alabama River drainage and consequently is a part of "Chunnennuggee Ridge". From central Bullock County near Inverness it is less prominent toward the east than farther west because Chunnennuggee Ridge bends nearly due north to the Enon cuesta scarp at the base of the Cusseta sand. The basal sand and gravel of the Ripley, however, continue to make a noticeable scarp eastward to the valley of the Pea River.

Beds of the Ripley formation above the basal sand are well exposed on Alabama Highway 9 between Sellers and Naftel, especially near Strata. Just west of Strata a cut on the highway in the NE¼ NW¼ sec. 7, T. 12 N., R. 18 E. shows the following section:

Section in cut of Alabama Highway 9 at Strata, Montgomery County

	Feet
Ripley formation:	
Gray glauconitic, micaceous, sandy clay containing *Exogyra cancellata, Anomia tellinoides,* and other fossils	11.0
Bed of slightly indurated sandy clay containing *Gryphaea mutabilis*	0.6
White micaceous, nonglauconitic sand in places indurated into thin lenticular sandstone beds; contains small oysters	5.0
	16.6

Nearly a mile farther south at the south edge of section 7 a cut on the highway exposes the following section:

Section on Alabama Highway 9 about 8/10 mile south-southeast of Strata, Montgomery County

	Feet
Ripley formation:	
Gray sparingly glauconitic, micaceous, clayey fine sand	13.0
Ferruginous sand	0.3
Medium-gray micaceous, clayey slightly harsh fine sand	4.5
Ferruginous sand	0.5
Loose micaceous, slightly glauconitic fine sand containing practically no clay	2.0
Soft fine-grained sandstone containing a few fossils	1.0
Yellow very glauconitic, micaceous fine sand containing abundant small oysters, mostly *Ostrea tecticosta* and *O. falcata*	7.0
	28.3

Half a mile farther south-southeast at a bend in the highway to south by west (SE¼ NE¼ sec. 18, T. 12 N., R. 18 E.) a foot of hard sandy limestone forms the top of the Ripley formation and is overlain disconformably by 23 feet of gray chalky clay of the Prairie Bluff chalk containing abundant phosphatic molds of fossils in the basal 2 feet.

Most of the exposures of the Ripley formation east of this highway in Montgomery County are on the upland and consist of rather featureless red sand. The basal coarse sand and the topmost bed of sandy limestone, however, are exposed on nearly every north-south road and can be traced across the county in detail.

On U. S. Highway 231 the village of Pine Level is built near the top of the scarp caused by the basal coarse sand of the Ripley. There are very few good exposures of the Ripley formation on the back slope of the High Ridge cuesta south of Pine Level, but paleontologists may be interested in a deposit of slightly sandy, micaceous, calcareous clay exposed in the ditches at the sides of the highway on a low hill near the southwest corner sec. 14, T. 12 N., R. 20 E., where very large specimens of *Anomia* sp. may be collected. The topmost layer of sandy limestone of the Ripley formation was not recognized along the highway, but the basal beds of the Prairie Bluff chalk are exposed on a northward-facing slope in the SW¼ NW¼ sec. 36, T. 12 N., R. 20 E., and the contact may be seen just west of the highway on the Lenora road in the SE¼

NE¼ sec. 35, where 5 feet of Prairie Bluff chalk (clay) containing phosphatic molds rests on 2 feet of light-gray compact calcareous sandstone. Langdon (50, pp. 428-429) described several outcrops of the limestone at the top of the Ripley and the overlying phosphatic Prairie Bluff marl in Crenshaw and Pike counties.

The High Ridge cuesta is a prominent feature of the geology of the southern part of Bullock County. The back-slope of the cuesta is very nearly a true dip slope on the top of the basal coarse sand and fine gravel of the Ripley formation. *Exogyra cancellata* was observed in ditches at the side of the road in the NE¼ NW¼ sec. 28, T. 12 N., R. 22 E., just 4 miles south of the top of the northward-facing scarp of the cuesta, and 135 feet below it. As the dip of the strata in this region is about 30 feet to the mile toward the south this fossiliferous deposit, which consists of gray and tan calcareous, clayey, glauconitic, micaceous fine sand, is at approximately the same stratigraphic position as the coarse sand and fine gravel exposed at the top of the scarp.

The coarse sand and fine gravel that forms the base of the Ripley formation produces a low scarp trending east by south across the county from Chunnennuggee Ridge through Inverness and Smut Eye to the Pea River Valley. In this region is exposed the black, laminated sandy clay mentioned by Langdon (50, p. 430). This constitutes a nearshore, unfossiliferous part of the Ripley formation.

The contact of the Ripley formation with the overlying Prairie Bluff chalk is well exposed at the top of a hill a little over a mile south-southeast of Omega, poorly exposed at the top of a hill on U. S. Highway 43 a mile north of Perote, and well exposed in a section a mile and a half (airline) east by north of Perote on the Smut Eye road (fig. 13).

Section east of road half a mile east by north of Perote in the NE¼ NW¼ sec. 7, T. 11 N., R. 24 E. Bullock County

	Feet
Providence sand:	
Highly micaceous, carbonaceous very fine sand	12
Prairie Bluff chalk:	
Finely sandy, chalky clay containing *Exogyra costata* and phosphatic molds of *Liopistha protexta*, *Scaphites* sp., *Baculites* sp., and other fossils	5
Calcareous, clayey fine sand containing *Exogyra costata*, *Gryphaea mutabilis*, *Anomia argentaria*, and other fossils; 1-foot layers of soft sandstone at top and bottom with phosphatic nodules in basal layer	11
Disconformity.	
Ripley formation:	
Yellow micaceous fine sand containing *Ostrea tecticosta*, *Gryphaea mutabilis*, *Anomia argentaria*, *Paranomia scabra*, and other fossils	21
Gray chalky clay containing *Gryphaea mutabilis* and *Anomia argentaria*	25
	74

Fig. 13.—Contact of the Ripley formation and the overlying Prairie Bluff chalk in sec. 7, T. 11 N., R. 24 E., Bullock County. The Prairie Bluff chalk, the base of which is indicated by the lower layer of sandstone, has not been recognized east of this exposure.

This locality is as far east as the Prairie Bluff chalk has been recognized. Farther east in Barbour County the basal calcareous beds of the Providence and Prairie Bluff are so sandy that they have been called Providence sand although it is recognized that they are of essentially the same age as the beds here designated Prairie Bluff chalk.

The upper part of the Ripley formation is exposed just southeast of Cooks Ford bridge in the SE¼ SE¼ sec. 10, T. 11 N., R. 24 E., where gray calcareous, clayey fine sand contains *Exogyra costata, Ostrea subspatulata, O. falcata, O. plumosa, Anomia argentaria,* and other fossils. The contact with the overlying Providence sand was not seen near here although the hills to the east are made up of white and pink micaceous sand and clay of the Providence.

East of Mount Andrew the Ripley formation is apparently completely overlapped by the Providence sand, which appears to rest directly on the Cusseta sand. The basal coarse sand bed of the Ripley is exposed on the Midway road (Alabama Highway 51) 1.1 miles north of Mount Andrew resting on gray and yellow micaceous, clayey very fine sand that is probably Cusseta. The contact dips about 10° toward the south suggesting that there may be some faulting nearby. This is further suggested by distortion of the bedding of Providence sand at the foot of the steep hill (Lapine cuesta) three-quarters of a mile north of Mount Andrew. The contact of the Ripley and the Providence was not seen on this highway but is exposed on the Comer road a mile east of Mount Andrew in the SW¼ SW¼ sec. 35, T. 12 N., R. 25 E.

Section in cut of Comer road a mile east of Mount Andrew, Barbour County

	Feet
Providence sand:	
Highly cross-bedded pink, red, and white coarse sand and gravel	4
Disconformity.	
Ripley formation:	
Mottled yellow and gray finely micaceous fine sand	28
	32

As explained in the section of this report on the Cusseta sand, the Providence sand is believed to rest directly on the Cusseta sand on the Comer-Clayton road. The Ripley is again well exposed 6 miles farther east on the Batesville-White Oak Springs

road. The contact with the Providence sand is near the top of the high hill (northward-facing scarp of the Lapine cuesta) 1¾ miles northwest of White Oak Springs in the NE¼ SE¼ sec. 20, T. 11 N., R. 27 E., where micaceous, carbonaceous fine sand of the Ripley formation is overlain sharply by sandy limestone and clay of the Providence sand containing pellets of phosphate and large cobbles of partly phosphatized sandstone.

At the foot of this high hill is 10 feet of gray clayey coarse sand of the Ripley containing large pillow-shaped concretions and *Exogyra costata, Gryphaea mutabilis, Anomia argentaria,* and *Ostrea plumosa.* This part of the Ripley formation is much better exposed 2 miles up the dip at the top of a hill in the NE¼ NW¼ sec. 9, T. 11 N., R. 27 E.

Section on Batesville road 4 miles (airline) north by west of White Oak Springs, Barbour County

	Feet
Ripley formation:	
Greenish yellow fine sand that weathers yellow	30.0
Hard calcareous fossiliferous sandstone	0.5
Soft greenish-buff clayey fossiliferous sand containing a nodular layer of indurated sand a foot above base	5.0
Hard calcareous fossiliferous sandstone	0.7
Soft greenish-gray clayey sand; in part indurated	12.0
	48.2

All these beds pass laterally because of weathering into greenish-gray sandy clay. Fossils observed include *Exogyra costata, Gryhaea mutabilis, Anomia argentaria, Paranomia scabra,* and a crab. The contact of the Ripley with the underlying Cusseta sand was not seen on this road, but it probably reaches the surface on this hill not far below the exposure.

The basal beds of the Ripley can be seen on the Eufaula-Midway road (Alabama Highway 6) three quarters of a mile west-northwest of Lugo and on the Spring Hill road 1.2 miles north of Lugo. I have not seen them farther east.

About 130 feet of Ripley is exposed below slumped or faulted beds of the Providence sand on the old Eufaula-Seale road in sections 5, T 11 N., R. 29 E., and 32, T. 12 N., R. 29 E., where yellow and buff micaceous sand contains numerous fossils of Ripley age including *Ostrea subspatulata.*

The contact of the Ripley formation with the overlying Providence sand is exposed in several cuts on the road that runs northwest from Eufaula along the crest of the Lapine cuesta. One of the best exposures of this contact is in the SE¼ SE¼ sec. 8, T. 11 N., R. 28 E., 0.2 mile west of a church and school, about 7 miles northwest by west of Eufaula.

Section in road cut about 7 miles northwest by west of Eufaula, Barbour County

	Feet
Providence sand:	
Compact light-brown sandy clay containing many small pebbles	13
Disconformity.	
Ripley formation:	
Yellow micaceous fine sand containing two 1-inch beds of coarse sand	9
	22

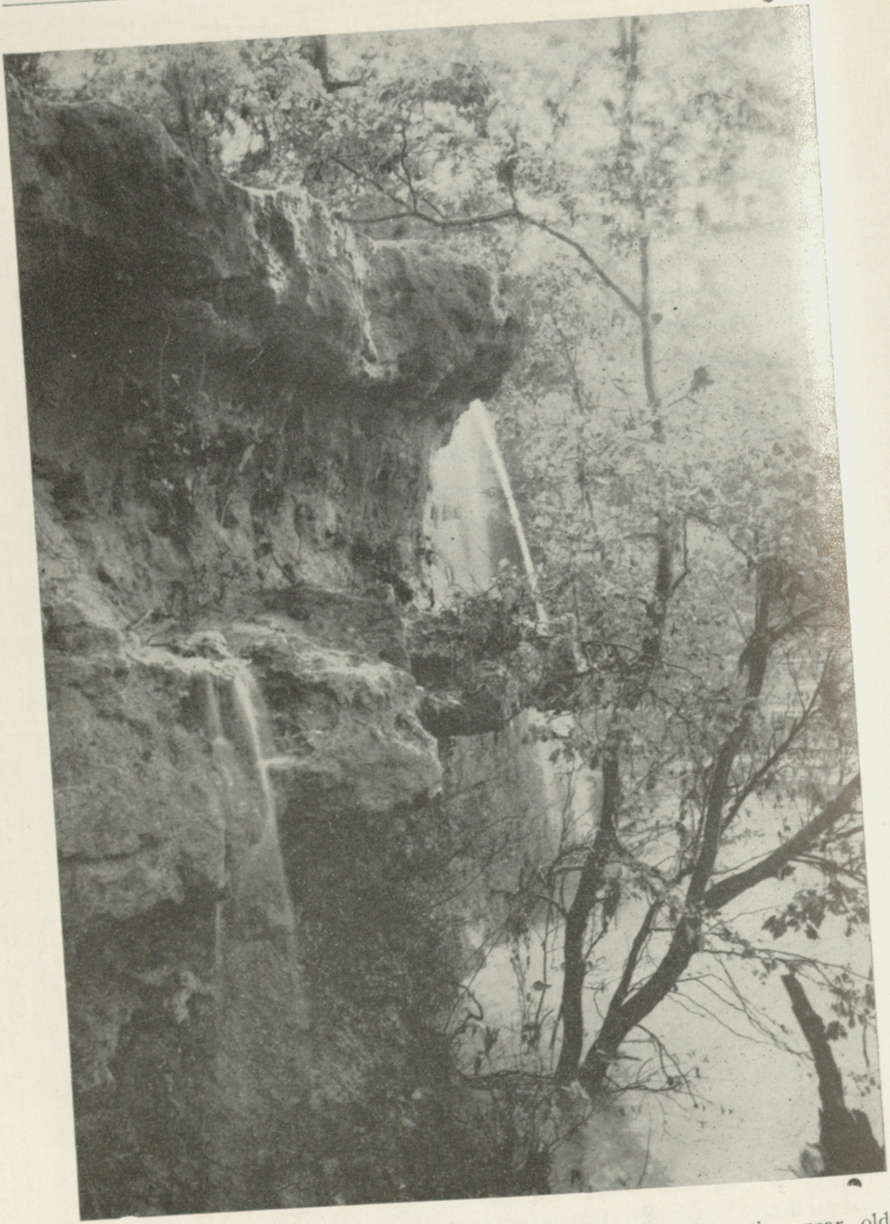

Fig. 14.—Sandy limestone at the top of the Ripley formation near old Alexanders Landing on the Chattahoochee River in sec. 9, T. 9 N., R. 29 E., Barbour County. The limestone contains many large echinoids. Photographed after a heavy rain.

Few exposures of the Ripley formation along the Chattahoochee River were examined during this investigation except the massive sandy limestone beds (fig. 14) at the top of the formation which are well exposed near Alexanders Landing in the SE¼ NW¼ sec. 9, T. 9 N., R. 29 E., Barbour County. The portion of Langdon's description of strata exposed on the Chattahoochee River (50, p. 442) that includes beds now interpreted as Ripley, Providence, and basal Midway is given here for the benefit of those who may not have ready access to his papers. Side headings are added to show my correlation of his description.

Part of Langdon's description of strata exposed on the Chattahoochee River (50, p. 442) including beds of Midway, Providence and Ripley Ages

	Feet
[Midway group:]	
39. Massive sandstone; coarse-grained and almost a conglomerate	8
38. Massive blue clay; contains a few bits of teredo-eaten lignite (probably top of Cretaceous) [?]	6
37. White coarse conglomerate, the matrix material being calcareous. The quartzose pebbles decrease in size toward the top, and the stratum becomes more argillaceous. There are many casts, but all too obscure for identification	18
[Providence sand:]	
36. Gray sand, with indurated ledges; no fossils seen; merges gradually in the upper part into a dark, almost black, sand containing large nodular masses and interstratified with light-yellow sands	35
35. Hard sandy ledge; weathered surface jagged; contains *Exogyra costata*, Say, and echinoids; very light yellow in color, white when dry and not weathered	30
34. Light-yellow sand, interstratified very irregularly with a gray micaceous sand filled with friable Ripley fossils; mouth of Pataula creek, Georgia	30
33. Brown laminated argillaceous sand; disappears at the mouth of Pataula creek, Georgia	5
32. Gray fossiliferous sand, with bowlders. The sand is massive, and is fossil-bearing only in the lowest 5 feet	40
[Ripley formation:]	
31. Yellow sands and indurated ledges filled with casts, *Exogyra costata*, Say, and echinoids set fast in the ledges. The sands are crossbedded and contain some lignite streaks	35
30. Calcareous gray sands, with bowlders	50
29. Light-yellow cross-bedded sands enclosed between indurated ledges	20
28. A more calcareous sand, filled with *Exogyra costata*, Say, and many indurated ledges, giving rise to the first bar below Eufaula	70

		Feet
27.	Massive gray sand, with a few fragile fossils and bowlders. This sand is only slightly calcareous, and is more or less lignitic; dip here about 100 feet to the mile	40
26.	Light-gray and yellow sands interlaminated with sand darker in color, more argillaceous, and containing bits of lignitized leaves and twigs; no other fossils seen; crops out in the gullies of Eufaula next below the Orange sand	20
25.	Gray calcareous sand, with indurated ledges, containing *Exogyra costata* Say; *Gryphaea vesicularis* Lam.; *Hamulus onyx, Plicatula urticosa, Anomia,* sp.; forms the shoal at Frances bar and bluff at Eufaula, Alabama	190
		597

Fig. 15.—Contact of the Ripley formation and the overlying Providence sand (marine facies) on right bank of White Oak Creek in sec. 16, T. 9 N., R. 29 E., Henry County. The Ripley (below) consists of sand and concretionary sandstone; the Providence of darker clayey sand.

Langdon's section may not have been correlated correctly here, but his description of bed 24, included in the discussion of the Cusseta sand, suggests material in the Cusseta a few miles west of the river; and the hard sandy ledges in bed 31 are probably those exposed at Alexanders Landing at the top of the Ripley formation. The actual contact of the Ripley and the Providence is exposed on White Oak Creek at the crossing of the power line in sec. 16, T. 9 N., R. 29 E., about three-quarters of a mile above the mouth of the creek, where the sandy limestone of the Ripley is overlain by a basal cobble-bearing bed of the Providence sand (fig. 15).

Thickness.—The part of the quoted section (50, p. 442) ascribed to the Ripley comprises about 425 feet of beds. Such a thickness seems excessive and suggests either that the proposed correlation of Langdon's section is wrong or that folding or faulting of the strata along the river caused him to obtain false figures for this part of his section. Until some geologist familiar with the present classification of the Upper Cretaceous deposits measures the thickness of the strata exposed on the Chattahoochee River, Langdon's estimates of thickness should be accepted.

On the hill overlooking the valley of Cowikee Creek on the old Eufaula-Seale road 130 feet of Ripley is exposed, but this figure may not represent the maximum thickness of the formation, for the Providence sand at the top of the hill shows signs of faulting or slumping and the Cusseta sand has not been definitely identified at the foot of the hill.

On the Batesville-White Oak Springs road estimates can be made of the thickness of the exposed part of the Ripley although the lower contact of the formation has not been observed. From aneroid readings on the different beds accessible along this road it is estimated that the Ripley here is between 100 and 135 feet thick, but part of the formation is probably concealed by overlapping Providence sand.

In the western part of Montgomery County the thickness of the formation probably does not much exceed 100 feet. Farther west the thickness varies along the strike from less than 100 feet to probably about 200 feet depending on the degree of overlap of the Prairie Bluff chalk. In Sumter County the maximum measured thickness of the formation is 81 feet, but this does not include

the top of the formation. In that region the thickness is probably of the order of 100 feet, but accurate measurements are hard to make because of the great amount of faulting in the region, which in places drops the Prairie Bluff chalk against the Demopolis member of the Selma chalk, all the Ripley being cut out. In adjacent parts of Mississippi the Ripley (chalky facies) slightly exceeds 60 feet in thickness.

Stratigraphic relations.—The Ripley formation rests conformably on the Demopolis member of the Selma chalk from the Mississippi State line eastward through Lowndes County, but in the eastern part of Sumter County the uppermost part of the Demopolis member merges laterally toward the east into sand which is included in the Ripley formation. This takes place by intertonguing—a tongue of chalk extending to the east above a westward-extending tongue of sand. In the western part of Montgomery County the Ripley rests on a westward-extending tongue of the Cusseta sand, equivalent to the upper part of the Demopolis member of the Selma. The contact is probably conformable, but farther east the contact appears to be disconformable and in Barbour County the contact is almost certainly a disconformity.

In Sumter County the Ripley formation is overlain unconformably by the Prairie Bluff chalk. The unconformity is marked by a sharp change in lithology from micaceous, finely sandy chalk in the Ripley to coarsely sandy, less micaceous chalk in the Prairie Bluff, by abundance of phosphatic pellets and phosphatic molds of mollusks in the overlying Prairie Bluff chalk, and by borings into the Ripley filled with Prairie Bluff material. Throughout much of Marengo and Wilcox Counties the Ripley is overlain unconformably by sand and clay of the Midway group (Paleocene) that has overlapped the Prairie Bluff chalk. At Prairie Bluff on the Alabama River, however, a thin section of Prairie Bluff chalk is present between the Ripley and the Midway, and this chalk rests on the Ripley with an angular unconformity. The angle between the strata of the Ripley, which dip down-stream, and the nearly horizontal Prairie Bluff chalk is about 10°.

From Dallas County eastward to the eastern part of Bullock County the Ripley is overlain disconformably by the Prairie Bluff chalk, but farther east it is overlain disconformably by the sandy equivalent of the chalk, the Providence sand.

As now defined the Ripley formation is entirely within the *Exogyra costata* zone. In the western three quarters of Sumter County the Ripley includes the part of the Upper Cretaceous series between the top of the *Exogyra cancellata* zone and the unconformity that forms the base of the Prairie Bluff chalk, an unconformity that is probably present throughout the Gulf Coastal Plain. East of Sumter County, however, the Ripley also includes the upper half of the *Exogyra cancellata* zone because of the intertonguing of the Ripley with the Demopolis member of the Selma chalk as described above.

The Ripley formation of western Sumter County was deposited at the same time as the lower part of the Ripley in the type area in Union and Tippah Counties, Mississippi. East of Sumter County the Ripley of Alabama includes beds older than any assigned to the Ripley in Mississippi, except in the extreme northern part where the Coon Creek tongue also includes strata within the *Exogyra cancellata* zone.

According to Stephenson (100) the Ripley is the time equivalent of the Nacatoch sand of Texas and Arkansas, the upper part of the Peedee formation of the Carolinas, and the Navesink marl of New Jersey. In terms of the European section the Ripley is of Maestrichtian age.

Physiographic expression.—In Mississippi the sand, clay, and limestone of the Ripley formation crop out in the Pontotoc Hills, which rise notably above the low Black Prairie belt to the east. In the same way the deposits of the Ripley formation in Alabama form a steep northward-facing scarp overlooking the Black Prairie belt to the northeast and north. This belt has long been called the Chunnennuggee Ridge, but as explained in the section discussing the physical geography of the Upper Cretaceous it seems better to refer to this physiographic district as the Chunnennuggee Hills as in eastern Alabama the belt contains several ridges.

The resistant strata of the Ripley formation give rise to the High Ridge cuesta, which overlooks the Black Prairie belt west of Montgomery County and forms one of the several cuestas of the Chunnennuggee Hills east of Montgomery County. The scarp of the High Ridge cuesta has its greatest development in the western half of Bullock County and the eastern half of Montgomery County, where it rises 120 to 150 feet above the lower land to the north that forms the back slope of the Enon cuesta.

Its back slope is drained by tributaries of Conecuh River and is very nearly a true dip slope. Aneroid observations were made at the crest of High Ridge (sec. 4, T. 12 N., R. 22 E.) and at an outcrop of sandy clay that contains *Exogyra cancellata* 3.8 miles due south on a local road at the north edge of sec. 28, T. 12 N., R 22 E. These showed a difference in altitude of 135 feet, which indicates a slope of about 33 feet to the mile. As the dip in this region approximates 30 feet to the mile to the south, this part of the back slope of the cuesta is a dip slope. The same conditions hold 3 miles farther east between Omega and Jenkins Crossroads, except that *Exogyra cancellata* was not found.

East of Jenkins Crossroads, which is near the place where Chunnennuggee Ridge makes its bend due north into the Enon cuesta, the High Ridge cuesta is not so prominent a feature of the topography, but nevertheless, it can be traced readily to the east into Barbour County. Near Mount Andrew where the Providence sand overlaps the Ripley its cuesta scarp (Lapine cuesta), intersects and replaces the High Ridge cuesta, so that the latter is not seen for many miles (pl. 2). However in the eastern half of Barbour County the Ripley is again exposed and the High Ridge cuesta becomes a strong topographic feature which trends northeast toward the Chattahoochee valley.

In the western part of Montgomery County the Ripley formation rests on the Demopolis member of the Selma chalk and from there west to the Mississippi State line the High Ridge cuesta scarp faces the Black Prairie belt. The scarp is not present in the valleys of the Alabama and Tombigbee Rivers, which are bordered by terrace deposits, but in interstream areas the cuesta scarp rises high above the Black Prairie belt to the north. In the east-central part of Sumter County, within the limits of the Epes quadrangle, the scarp has an altitude of 100 to 150 feet above the lowland to the north. The back slope in this region drops 200 feet in 4 miles indicating a slope of 50 feet to the mile, but the slope is not a true dip slope, for the rocks are highly faulted and only the more resistant rocks of the Prairie Bluff chalk in the dropped blocks affect the topography appreciably.

In eastern Alabama the High Ridge cuesta is bordered on the south by the northward-facing scarp of the Lapine cuesta, but this cuesta dies out in Lowndes County, and to the west the scarp

to the south is the Troy cuesta, which is caused by the resistant rocks of the lower part of the Clayton formation. In Marengo County the Troy cuesta also dies out because the lower part of the Clayton formation there passes laterally into the Sucarnoochee (Porters Creek in Mississippi) clay, and from Marengo County into Mississippi the back slope of the High Ridge cuesta merges southwest into the Flatwoods which are underlain by the Sucarnoochee and Porters Creek clay. Locally beds of sand at the base of the Sucarnoochee cause low hills that might be considered western extensions of the Troy scarp.

BIBLIOGRAPHY

1. Morton, S. G., Description of two new species of fossil shells of the genera *Scaphites* and *Crepidula;* with some observations on the ferruginous sand, plastic clay, and upper marine formations of the United States: Acad. Nat. Sci. Philadelphia Jour., vol. 6, p. 127, 1829.

2. Morton, S. G., Supplement to the "Synopsis of the organic remains of the ferruginous sand formation of the United States," contained in vols. XVII and XVIII of this Journal: Am. Jour. Sci., 1st ser., vol. 23, p. 288, 1833.

3. Withers, R. W., Geological notices respecting a part of Greene County, Alabama: Am. Jour. Sci., 1st ser., vol. 24, pp. 187-189, 1833.

4. Shepard, C. U., Geological observations upon Alabama, Georgia, and Florida: Am. Jour. Sci., 1st ser., vol. 25, pp. 162-173, 1833.

5. McGuire, W .W., On the prairies of Alabama: Am. Jour. Sci., 1st ser., vol. 26, pp. 93-98, 1834.

6. Morton, S. G., Synopsis of the organic remains of the Cretaceous group of the United States, pp. 21-24, Philadelphia, 1834.

7. Morton, S. G., Notice of the fossil teeth of fishes of the United States, the discovery of the Galt in Alabama, and a proposed division of the American Cretaceous group: Am. Jour. Sci., 1st ser., vol. 28, pp. 276-278, 1835.

8. Brumby, R. T., Mineral resources of Alabama, in F. A. P. Barnard's Alabama State Almanac for the year 1834, pp. 65-80, 1839 (?).

9. Morton, S. G., Description of some new species of organic remains of the Cretaceous group of the United States, with a tabular view of the fossils hitherto discovered in this formation: Acad. Nat. Sci. Philadelphia Jour., vol. 8, pp. 207-227, 1842.

10. Kain, J. H., On the Prairies of Alabama (abstract): Assoc. Am. Geologists Proc., vol. 6, p. 68, 1845.

11. Lyell, Charles, A second visit to the United States of North America, vol. 2, 371 pp., New York and London, 1849.

12. Tuomey, Michael, First biennial report on the geology of Alabama, pp. 116-142, Tuscaloosa, 1850.

13. Tuomey, Michael, Description of some new fossils from the Cretaceous rocks of the southern States : Acad. Nat. Sci. Philadelphia Proc., vol. 7, pp. 167-172, 1854.

14. Winchell, Alexander, On the geology of the Choctaw Bluff: Am. Assoc. Adv. Sci. Proc., vol. 7, pp. 150-153, 1856.

15. Mallet, J. W., Results of some analyses made for the Geological Survey of the State of Alabama: Am. Jour. Sci., 2d ser., vol. 23, pp. 181-185, 1857.

16. Winchell, Alexander, Notes on the geology of middle and southern Alabama: Am. Assoc. Adv. Sci. Proc., vol. 10, pt. 2, pp. 90-93, 1857.

17. Winchell, Alexander, Statistics of some artesian wells of Alabama: Am. Assoc. Adv. Sci. Proc., vol. 10, pt. 2, pp. 94-103, 1857.

18. Hall, James, Observations upon the Cretaceous strata of the United States with reference to the relative position of fossils collected by the boundary commission: Am. Jour. Sci., 2d ser., vol. 24, pp. 72-86, 1857.

19. Harper, Lewis, *Ceratites americanus*: Acad. Nat. Sci. Philadelphia Proc., vol. 8, pp. 126-128, 1857.

20. Tuomey, Michael, Second biennial report on the geology of Alabama, pp. 128, 134-142, 186-190, Montgomery, 1858. (Edited by J. W. Mallet)

21. Thornton, E. Q., Reports on portions of the Cretaceous and Tertiary formations; in Tuomey, Michael, Second biennial report on the geology of Alabama, pp. 227-244, 1858.

22. Conrad, T. A., Descriptions of new species of Cretaceous and Eocene fossils of Mississippi and Alabama: Acad. Nat. Sci. Philadelphia Jour., 2d ser., vol. 4, pp. 275-298, 1860.

23. Gabb, W. M., Descriptions of some new species of Cretaceous fossils: Acad. Nat. Sci., Philadelphia Jour., 2d ser., vol. 4, pp. 299-305, 1860.

24. Gabb, W. M., Descriptions of new species of American Tertiary and Cretaceous fossils: Acad. Nat. Sci. Philadelphia Jour., 2d ser., vol. 4, pp. 289-406, 1860.

25. Gabb, W. M., Description of a new species of *Cassidulus,* from the Cretaceous formation of Alabama: Acad. Nat. Sci. Philadelphia Proc. 1860, p. 519.

26. Hilgard, E. W., Report on the geology and agriculture of the State of Mississippi, 391 pp., Jackson, 1860.

27. Gabb, W. M., Description of new species of Cretaceous fossils from New Jersey, Alabama, and Mississippi: Acad. Nat. Sci. Philadelphia Proc. 1861, pp. 318-330.

28. Gabb, W. M., Notes on Cretaceous fossils with descriptions of a few additional new species. Acad. Nat. Sci. Philadelphia Proc. 1861, pp. 363-367.

29. Conrad, T. A., Note on the genus *Gadus,* with descriptions of some new genera and species of American fossil shells: Am. Jour. Conch., vol. 2, pp. 75-78, 1866.

30. Leidy, Joseph, (On reptilian remains from Colorado, Pickens Co., Ala., and Wyoming): Acad. Nat. Sci. Philadelphia Proc. 1870, p. 4.

31. Hilgard, E. W., On the geological history of the Gulf of Mexico: Am. Assoc. Adv. Sci. Proc., vol. 20, pp. 222-225, 1872; *also* Am. Jour. Sci., 3d ser., vol. 2, pp. 391-394, 1871.

32. Webb, R. D., The relation of geological formations and of soils to malarial fevers, as exemplified in Sumter County, Alabama: Alabama Med. Assoc. Trans., vol. 34, pp. 285-306, 1881.

33. Miller, S. A., Description of ten new species of fossils: Cincinnati Soc. Nat. Hist. Jour., vol. 5, pp. 86-88, 1882.

34. DeLoriol, P., Description of a new species of *Bourgueticrinus*: Cincinnati Soc. Nat. Hist. Jour., vol. 5, p. 118, 1882.

35. Schlumberger, C., Remarks upon a species of *Cristellaria*: Cincinnati Soc. Nat. Hist., Jour., vol. 5, p. 119, 1882.

36. Smith, E. A., Report for the years 1881 and 1882, embracing an account of the agricultural features of the State: Alabama Geol. Survey, 615 pp., 1883.

37. Smith, E. A., Report on the cotton production of the State of Alabama with a discussion of the general agricultural features of the State: U. S. Tenth Census, vol. 6, pp. 9-56, 77-148, 1884.

38. Johnson, L. C., (Note on the Ripley group in Intelligence from American scientific stations): Science, 1st. ser., vol. 3, p. 80, Jan. 18, 1884.

39. Smith, E. A., Phosphatic deposits in the Cretaceous of Alabama: Am. Jour. Sci., 3d ser., vol. 27, pp. 492-493, 1884.

40. Smith, E. A., Cretaceous phosphates in Alabama: Science, 1st. ser., vol. 3, pp. 586-587, 1884.

41. Smith, E. A., Cretaceous phosphates in Alabama: Science, 1st ser., vol. 4, pp. 78-79, 1884.

42. Smith, E. A., Report on the phosphates of Alabama: Alabama Dept. Agriculture Bull. 5, pp. 6-19, 1884.

43. Smith, E. A., and Johnson, L. C., Tertiary and Cretaceous strata of the Tuscaloosa, Tombigbee, and Alabama Rivers: U. S. Geol. Survey Bull. 43, pp. 15-18, 71-117, 131-138, 169-182, 1887.

44. Smith, E. A., Report of Progress for the years 1884-8: Alabama Geol. Survey, map, 1888.

45. Langdon, D. W., Jr., Variations in the Cretaceous and Tertiary strata of Alabama: Geol. Soc. America Bull., vol. 2, pp. 587-606, 1891.

46. Spencer, J. W., A general or preliminary report on southwest Georgia: Georgia Geol. Survey 1st Rept. Progress, pp. 26-40, 1891.

47. Langdon, D. W., Geological section along the Chattahoochee River from Columbus to Alum Bluff: Georgia Geol. Survey, 1st Rept. Progress, pp. 90-94, 1891.

48. Smith, E. A., Sketch of the geology of Alabama, 36 pp., 1892.

49. Smith, E. A., Phosphates and marls of Alabama: Alabama Geol. Survey Bull. 2, 82 pp. 1892.

50. Smith, E. A., Johnson, L. C., and Langdon, D. W., Jr., Report on the geology of the Coastal Plain of Alabama; Alabama Geol. Survey, 759 pp., 1894.

51. Smith, E. A., Alabama's resources for the manufacture of Portland cement: Alabama Sci. Ind. Soc. Proc., vol. 5, pp. 44-51, 1895.

52. Smith, E. A., The phosphates and marls of Alabama: Am. Inst. Mining Engineers Trans., vol. 25, pp. 811-822, 1896.

53. Smith, E. A., The cement resources of Alabama: U. S. 58th Cong., 1st sess., S. Doc. 19, pt. 2, pp. 11-17, 21-23, 1903.

54. Smith, E. A., Cement resources of Alabama: U. S. Geol. Survey Bull. 225, pp. 434-447, 1903.

55. Smith, E. A., The cement resources of Alabama: Alabama Geol. Survey Bull. 8, pt. 2, pp. 76-86, 1904.

56. Smith, E. A., Alabama, in Fuller, M. L., and others, Contributions to the hydrology of eastern United States: U. S. Geol. Survey Water-Supply Paper 102, pp. 276-331, 1904.

57. Eckel, E. C., and Crider, A. F., Geology and cement resources of the Tombigbee River district, Mississippi-Alabama: U. S. 58th Cong., 3d sess., S. Doc. 165, 23 pp., 1905.

58. Smith, E. A., Alabama, in Fuller, M. L., and others, Underground waters of eastern United States: U. S. Geol. Survey Water-Supply Paper 114, pp. 164-170, 1905.

59. Smith, E. A., Portland cement materials of Alabama: U. S. Geol. Survey Bull. 243, pp. 71-84, 1905.

60. Smith, E. A., The underground water resources of Alabama: Alabama Geol. Survey, pp. 12-14, 108-244, 1907.

61. Sutherland, W. J., Physiography of the Gulf coastal plains: Jour. Geog., vol. 6, pp. 336-347, 1908.

62. Veatch, Otto, Second report on the clay deposits of Georgia: Georgia Geol. Survey Bull. 18, pp. 82-106, 1909.

63. Smith, E. A., Cretaceous-Eocene contact, Tombigbee River, Alabama: Jour. Geol., vol. 18, pp. 430-434, 1910.

64. Harper, R. M., A botanical and geological trip on the Warrior and Tombigbee rivers in the Coastal Plain of Alabama: Torrey Bot. Club Bull., vol. 37, pp. 106-126, 1910.

65. Veatch, Otto, and Stephenson, L. W., Preliminary report on the geology of the Coastal Plain of Georgia: Georgia Geol. Survey Bull 26, pp. 1-215, 1911.

66. Gilmore, C. W., A new mosasauroid reptile from the Cretaceous of Alabama: U. S. Nat. Museum Proc., vol. 41, pp. 479-484, 1912.

67. Harper, R. M., Economic botany of Alabama, Part 1, Geographical report on forests: Alabama Geol. Survey Monograph 8, 222 pp., 1913.

68. Smith, E. A., Portland cement resources of Alabama: U. S. Geol. Survey Bull. 522, pp. 77-89, 1913.

69. Stephenson, L. W., Cretaceous deposits of the eastern Gulf region and species of *Exogyra* from the eastern Gulf region and the Carolinas: U. S. Geol. Survey Prof. Paper 81, 77 pp., 1914.

70. Stephenson, L. W., The Cretaceous-Eocene contact in the Atlantic and Gulf Coastal Plain: U. S. Geol. Survey Prof. Paper 90-J, pp. 155-182, 1915.

71. Stephenson, L. W., Tongue, a new stratigraphic term, with illustrations from the Mississippi Cretaceous: Washington Acad. Sci. Jour., vol. 7, pp. 243-250, 1917.

72. Berry, E. W., Upper Cretaceous floras of the eastern Gulf region in Tennessee, Mississippi, Alabama, and Georgia: U. S. Geol. Survey Prof. Paper 112, p. 38, 1919.

73. Gilmore, C. W., New fossil turtles, with notes on two described species: U. S. Nat. Museum Proc., vol. 56, pp. 123-125, 1919.

74. Brantly, J. E., Petroleum possibilities of Alabama, Coastal Plain area: Alabama Geol. Survey Bull. 22, pt. 2, pp. 123-143, 1920.

75. Cleland, H. F., A Pleistocene peneplain in the Coastal Plain: Jour. Geol., vol. 28, pp. 702-706, 1920.

76. Stephenson, L. W., Invertebrate fossils of the Upper Cretaceous formations: North Carolina Geol. and Econ. Survey, vol. 5, pt. 1, 604 pp., 1923.

77. Stephenson, L. W., The Mesozoic rocks, in Adams, G. I., Butts, Charles, Stephenson, L. W., and Cooke, Wythe, Geology of Alabama: Alabama Geol. Survey Spec. Rept. 14, pp. 231-250, 1926.

77A. Stephenson, L. W., Structural features of the Atlantic and Gulf Coastal Plain (abstract): Geol. Soc. America Bull., vol. 39, p. 179, 1928; Pan-Am. Geologist, vol. 29, pp. 140-141, 1928.

77B. Stephenson, L. W., Major marine transgressions and regressions, and structural features of the Gulf Coastal Plain (abstract): Pan-Am. Geologist, vol. 49, pp. 301-302, 1928; Geol. Soc. America Bull., vol. 39, pp. 275-276, 1928.

77C. Stephenson, L. W., Upper Cretaceous or Gulf series (abstract): Geol. Soc. America Bull., vol. 39, p. 276, 1928; Pan-Am. Geologist, vol. 49, p. 295, 1928.

78. Stephenson, L. W., Major marine transgressions and regressions and structural features of the Gulf Coastal Plain: Am. Jour. Sci., 5th ser., vol. 16, pp. 281-298, 1928.

79. Stephenson, L. W., Structural features of the Atlantic and Gulf Coastal Plain: Geol. Soc. America Bull., vol. 39, pp. 887-899, 1928.

79A. Stephenson, L. W., Correlation of the Upper Cretaceous or Gulf series of the Gulf Coastal Plain: Am. Jour. Sci., 5th ser., vol. 16, pp. 485-496, 1928.

80. Adams, G. I., The streams of the Coastal Plain of Alabama and the Lafayette problem: Jour. Geol., vol. 37, pp. 193-203, 1929.

81. Semmes, D. R., Oil and gas in Alabama: Alabama Geol. Survey Spec. Report 15, pp. 201-399, 1929.

82. Sandidge, J. R., Significant foraminifera from the Ripley formation of Alabama: Am. Midland Naturalist, vol. 13, pp. 190-202, 1932.

83. Sandidge, J. R., Foraminifera from the Ripley formation of western Alabama: Jour. Paleontology, vol. 6, pp. 265-287, 1932.

84. Sandidge, J. R., Fossil foraminifera from the Cretaceous Ripley formation of Alabama: Am. Midland Naturalist, vol. 13, pp. 312-318, 1932.

85. Sandidge, J. R., Additional foraminifera from the Ripley formation in Alabama: Am. Midland Naturalist, vol. 13, pp. 333-376, 1932.

86. Stephenson, L. W., The zone of *Exogyra cancellata* traced twenty-five hundred miles: Am. Assoc. Petroleum Geologists Bull., vol. 17, pp. 1351-1361, 1933.

87. Renger, J. J., Prehistoric marine reptiles from the Cretaceous of Alabama: Rocks and Minerals, vol. 9, pp. 109-111, 1934.

88. Stephenson, L. W., The genus *Diploschiza* from the Upper Cretaceous of Alabama and Texas: Jour. Paleontology, vol. 8, pp. 273-280, 1934.

89. Galliher, E. W., Glauconite genesis: Geol. Soc. America, Bull., vol. 46, pp. 1351-1366, 1935; Geology of glauconite: Am. Assoc. Petroleum Geologists Bull., vol. 19, pp. 1569-1601, 1935.

90. Renger, J. J., Excavation of Cretaceous reptiles in Alabama: Sci. Monthly, vol. 41, pp. 560-565, 1935; *see also* Science, new ser., vol. 82, no. 2120, sup., p. 7, Aug. 16, 1935.

91. Stephenson, L. W., Further notes on the Cretaceous pelecypod genus *Diploschiza*: Jour. Paleontology, vol. 9, pp. 588-592, 1935.

92. Stephenson, L. W., New Upper Cretaceous Ostreidae from the Gulf region: U. S. Geol. Survey Prof. Paper 186-A, pp. 1-12, 1936.

93. Stephenson, L. W., Flat-bottomed stream erosion by wetting and drying (abstract): Washington Acad. Sci. Jour., vol. 27, p. 220, 1937.

94. Stephenson, L. W., and Monroe, W. H., Prairie Bluff chalk and Owl Creek formation of eastern Gulf region: Am. Assoc. Petroleum Geologists Bull., vol. 21, pp. 806-809, 1937.

95. Fenneman, N. M., Physiography of eastern United States, pp. 65-83, 1938.

96. Stephenson, L. W., and Monroe, W. H., Stratigraphy of Upper Cretaceous series in Mississippi and Alabama: Am. Assoc. Petroleum Geologists Bull., vol. 22, pp. 1639-1657, 1938.

97. Cooke, C. W., Geologic map of Georgia, Coastal Plain: Georgia Div. Mines, Mining and Geology, 1939.

98. Monroe, W. H., Cretaceous field trip of the Mississippi Geological Society: Mississippi Geol. Soc. Guidebook, 30 pp. 1940.

99. Munyan, A. C., Supplementary investigations of Alabama bleaching clays: U. S. Geol. Survey Bull. 901, pp. 243-249, 1940.

100. Stephenson, L. W., King, P. B., and Monroe, W. H., Correlation of the outcropping Cretaceous formations of the Atlantic and Gulf Coastal Plain and Trans-Pecos Texas: Unpublished correlation chart.

INDEX

Page

A

Acknowledgement of aid 13, 14
Ada, Selma chalk at 67
Adams, G. I., physiographic suggestions by 20
Alabama River, terraces of 43
Anacacho limestone correlated with Demopolis member of Selma chalk 72
Annona chalk correlated with Demopolis member of Selma chalk 72
Annona chalk, lower part, correlated with Blufftown formation 88
  lower part, correlated with lower marly member of Selma chalk 56
Arcola cuesta, description of 31, 63
Arcola limestone member of Selma chalk 58
  correlation of 63
  first mentioned 15
  in Bullock County 62
  in Dallas County 61, 62
  in Greene County 61
  in Hale County 59
  in Sumter County 61
  lithologic character of 58
  physiographic expression of 31, 63
  possibly represented in Blufftown formation 83, 93
  stratigraphic relations of 63
  thickness of 63
  type locality of 58, 60
Areal extent of the Upper Cretaceous formations 23
Arkansas, formations in, represented in Blufftown formation 88
  formations in, represented in Demopolis member of Selma chalk 72
    represented in lower marly member of Selma chalk 56
  Nacatoch sand in, equivalent to Ripley formation 127
Artesian wells in Black Prairie belt 15, 19, 34
Austin chalk, upper part, correlated with Blufftown formation 87
  upper part, correlated with lower marly member of Selma chalk 56

B

Bald spots in chalk 32
Barbour County, Blufftown formation in 75, 85, 86
  Cowikee prairie in 40
  Cusseta sand in 89, 91, 92, 97, 98
  Enon cuesta in 37, 101
  faulting in 46
  High Ridge cuesta in 41, 128
  Lapine cuesta in 42
  Ripley formation in 119-125
  Selma chalk in 54

INDEX—Continued

Page

Batesville, Cusseta sand near ... 89, 98
Beloit, Arcola limestone near ... 62
Bentonite in Blufftown formation ... 82
in Bullock County ... 93
in Cusseta sand ... 93
in Lowndes County ... 112-114
in Macon County ... 82
in Montgomery County ... 113-114
in Ripley formation ... 112-114
in Selma chalk ... 22
Bibliography ... 130
Biotite in Demopolis member of Selma chalk ... 68
Black Creek formation, lower part, correlated with lower marly member
member of Selma chalk ... 57
upper part, correlated with Demopolis member of Selma chalk ... 72
Black Prairie belt, description of ... 30, 57, 72
Blossom sand correlated with Blufftown formation ... 87
Bluffport, Selma chalk at ... 69
Blufftown, Cusseta sand at ... 89
Blufftown formation, bentonite in ... 82
correlation of ... 87
definition of ... 73
general relations of ... 25
in Barbour County ... 75, 85, 86
in Macon County ... 74, 78, 79, 81, 82
in Bullock County ... 83-85, 93
in Russell County ... 74, 79-81, 86
lithologic character of ... 75
overlapped by Cusseta sand ... 87
physiographic expression of ... 35, 88
relation to lower marly member of Selma chalk ... 55
stratigraphic relations of ... 86
thickness of ... 86
type locality of ... 74
Blufftown-Cusseta contact ... 83-85, 92, 93
Boligee, Arcola limestone near ... 61
Selma chalk near ... 68
Bonham marl correlated with Blufftown formation ... 87
Brackeen, L. G., work by ... 47
Brown, Andrew, work by ... 14, 67, 112
Brownstown marl correlated with Blufftown formation ... 88
correlated with lower marly member of Selma chalk ... 56
Bullock County, Arcola limestone in ... 62
bentonite in ... 93
Blufftown formation in ... 83-85, 93
Cusseta sand in ... 90, 93, 96, 98, 99

INDEX—Continued

Page

Bullock County—Continued

Enon cuesta in 36, 37, 101
High Ridge cuesta in 40, 128
Lapine cuesta in 42
Ripley formation in 117-119
Sand Fort cuesta in 36

C

Calcite crystals, prismatic, zone of 84, 85, 93
Cement rock in Alabama 18
in Demopolis member of Selma chalk 68
Chapman, L. C., well of 55
Chattahoochee River, Blufftown formation exposed on 77
Cusseta sand exposed on 91
Ripley formation exposed on 123
terraces of 44
Chesson, section of Eutaw and Selma near 54
Choctaw Bluff, section of Eutaw and Selma at 50
Chunnennuggee Hills, description of 34
Chunnennuggee Ridge, definition of 35
Cleland, H. F., physiographic work of 20, 33
Coffee sand, lower part, correlated with Blufftown formation 87
lower part, correlated with lower marly member of Selma chalk 56
Tupelo tongue, correlated with Demopolis member of Selma chalk 72
Collirene, section at 112
Comer, Cusseta sand near 89, 97
topography near 40
Comer salient defined 46
Conecuh Falls 38
Cooke, C. W., map by 57, 75, 86, 90
Correlation of Arcola limestone 63
of Blufftown formation 87
of Cusseta sand, *see* Correlation of Demopolis member of Selma chalk
of Demopolis member of Selma chalk 72
of lower marly member of Selma chalk 56
of Ripley formation 127
Cowikee prairie, definition of 40
Crenshaw County, Ripley-Prairie Bluff contact in 114
Cuesta, definition of 31
Cusseta sand, bentonite in 93
calcareous sand bed in 95-97
correlations of, *see* Correlation of Demopolis member of Selma chalk
definition of 89
general relations of 25
in Barbour County 97, 98
in Bullock County 93, 96, 98, 99

INDEX—Continued

Page

Cusseta sand—Continued
in Montgomery County 94, 95, 99
intertonguing with Selma chalk 94, 100
lithologic character of 91
physiographic expression of 36, 101
relation to Arcola limestone 62
relation to Demopolis member of Selma chalk 70
stratigraphic relations of 99
thickness of 99
type locality of 89
Cusseta-Blufftown contact 83-85, 92, 93
Cusseta-Providence contact 97
Cusseta-Ripley contact 99

D

Dancy, Selma chalk near 68
Dallas County, Arcola limestone in 61, 62
basal Selma chalk in 52
Demopolis member of Selma chalk in 67, 68
Ripley formation in 111
Demopolis, Arcola limestone near 58, 68
Selma chalk at 65, 66
Demopolis member of Selma chalk, cement rock in 68
correlation of 72
definition of 64
in Dallas County 67
in Marengo County 66
in Montgomery County 67
in Sumter County 66, 69
intertonguing with Cusseta sand 94, 100
intertonguing with Ripley formation 69, 108
lithologic character of 65
phosphate at base of 60, 62, 68
physiographic expression of 72
relations of, with Cusseta sand 70
stratigraphic relations of 70
thickness of 69
type locality of 65
Devenport, bentonite near 112-114
Diploschiza cretacea zone, description of 27
extent of 66
thickness of 70
Diploschiza cretacea striata zone, description of 27
extent of 67
Divisions of the Upper Cretaceous 23
Downs, section exposed near 78

INDEX—Continued

Page

Drainage of Enon cuesta 37
of High Ridge cuesta 41
Sand Fort cuesta 36

E

Elmore County, faulting in 14, 46
Emelle, faulting near 46
Englishtown sand correlated with Demopolis member of Selma chalk 72
Enon cuesta, Cusseta sand in 101
definition of 36
in Barbour County 101
in Bullock County 101
in Montgomery County 102
in Russell County 101
Epes, exposures near 66, 107, 108
Eufaula, exposures near 121
Eutaw, Eutaw-Selma contact near 50
Eutaw formation, description of 23
Eutaw-Blufftown contact 78-80
Eutaw-Selma contact 49-54
Exogyra cancellata zone, description of 28
extent of 69
in Ripley formation 108
thickness of 70
Exogyra costata zone, description of 28
Exogyra ponderosa zone, description of 27

F

Fall Line Hills 29
Faulting in Barbour County 46
in Elmore County 14, 46
in Marengo County 13, 46, 66
in Sumter County 13, 46, 104-106, 108
near Chattahoochee River 47
on Tombigbee River 108
Faunal zones in the Upper Cretaceous 27
Fenneman, N. M., physiographic divisions of 29
Flatwoods physiographic district 41
Fleta, exposures near 94
Flexible sandstone 84
Folding in Upper Cretaceous rocks 47
Fort Deposit, topography near 42

G

General features of the Upper Cretaceous formations 23
Georgia, Blufftown formation in 75
Cusseta sand in 90
Cusseta sand represents Demopolis member of Selma chalk in 72

INDEX—Continued

Page

Glenville, topography near 37, 88
Greene County, Arcola cuesta in 64
  Arcola limestone in 61
  basal Selma chalk in 50
  Demopolis member of Selma chalk in 68

H

Hale County, Arcola limestone in 59
  basal Selma chalk in 51
Hardaway, exposures near 54, 78
Harper, R. M., cited 19, 34
  physiographic divisions of 29
High Ridge cuesta, definition of 40
  in Montgomery and Bullock Counties 115, 117
  Ripley formation in 127
High Ridge, section on 96
Hilgard, E. W., cited 16, 102
Historical review 15-22
Hurtsboro, section exposed near 81

I

Itacolumite, rock resembling 84

J

Johnson, L. C., *see* Smith, E. A.
Jones Bluff, Selma chalk at 66

L

Lafayette formation 33, 44, 80, 104, 112
Langdon, D. W., cited 18, 35, 80, 86, 99, 117
  Blufftown formation described by 77
  Cusseta sand described by 91
  Ripley formation described by 123
  quoted 112
  see also Smith, E. A.
Lapine, cuesta, definition of 42
Linden, exposures near 110
Livingston bored well 55, 63, 69
Livingston fault zone 46, 104-106, 108
Livingston, Ripley formation near 105-107
Lowndes County, basal Selma chalk in 53
  bentonite in 112-114
  Eutaw formation in 53
  High Ridge cuesta in 41
  Lapine cuesta in 42
  Ripley formation in 112-114
Lugo, exposures near 98, 120

INDEX—Continued

Page

M

MacNeil, F. S., work by 13
Macon County, basal Selma chalk in 53
bentonite in 82
Blufftown formation in 74, 78, 79, 81, 82
Sand Fort cuesta in 36, 88
Marengo County, Demopolis member of Selma chalk in 66
Faulting in 13, 46, 66, 108
High Ridge cuesta in 41
Ripley formation in 110
Marlbrook marl correlated with Demopolis member of Selma chalk 72
Marshalltown formation correlated with Demopolis member of Selma chalk 72
Massillon, Selma chalk near 68
Matawan group, lower part, correlated with lower marly member of Selma chalk 57
McGlamery, Winnie, work by 13
Merchantville clay correlated with Blufftown formation 88
Mesas caused by outliers of Arcola limestone 32
Mesaverde formation correlated with Blufftown formation 87
Midway, section exposed near 85
Migration of rivers toward right banks 44
Minter, Ripley exposed near 111
Mississippi, Blufftown formation represented by Coffee sand in 87
formations in, represented in Demopolis member of Selma chalk 72
formations in, represented in lower marly member of Selma chalk 56
Monroe, W. H., *see* Stephenson, L. W.
Montgomery County, bentonite in 113-114
Cusseta sand in 90, 94, 95, 99
Demopolis member of Selma chalk in 67
Enon cuesta in 36, 102
High Ridge cuesta in 40, 128
intertonguing of Cusseta sand and Selma chalk in 70
Ripley formation in 112, 115-117
thickness of lower marly member of Selma chalk in 55
Morton, S. G., cited 15
Mount Andrew, exposures near 97, 119
structure near 46
Mount Carmel, Cusseta sand near 95, 99
Mount Laurel sand correlated with Demopolis member of Selma chalk 72
Munyan, A. C., bentonite deposits described by 22

N

Nacatoch sand correlated with Ripley formation 127
Navesink marl correlated with Ripley formation 127

INDEX—Continued

Page

New Jersey, formations in, represented in Blufftown formation 88
formations in, represented in Demopolis member of Selma chalk 72
represented in lower marly member of Selma chalk 57
Navesink marl in, equivalent to Ripley formation 127
New Mexico, Mesaverde formation in, correlated with Blufftown formation 81, 87
Neylandville marl correlated with Demopolis member of Selma chalk 72
North Carolina, formations in, represented in Demopolis member of Selma chalk 72
formations in, represented in lower marly member of Selma chalk 57
Peedee formation in, equivalent to Ripley formation 127

O

Old Spring Hill, Ripley exposed at 111
Ostrea elegantula zone, description of 27
in Russell County 81
Ox Level, section near 99
Ozan formation correlated with Blufftown formation 88
correlated with lower marly member of Selma chalk 56

P

Payne, Willard, work by 51
Peachburg, topography south of 37
Peedee formation correlated with Demopolis member of Selma chalk 72
correlated with Ripley formation 127
Peneplane, Pleistocene 33
Perote, Ripley-Prairie Bluff contact near 118
topography near 42
Phosphate in Alabama, discovery of 17
in Demopolis member of Selma chalk 60, 62, 68
in lower marly member of Selma chalk 49
Physical geography of the Upper Cretaceous deposits 29
Physiographic divisions 29
Physiographic expression of Arcola limestone 31, 63
of the Blufftown formation 35, 88
of the Cusseta sand 36, 101
of Demopolis member of Selma chalk 32, 72
of lower marly member of Selma chalk 30, 57
of Ripley formation 40, 127
Pickens County, basal Selma chalk in 49
Pickensville, Eutaw-Selma contact at 49
Pierce, G. R., work by 13, 69
Pine Level, Ripley exposed near 116
Pike County, Troy cuesta in 42
Piracy of Conecuh River 38
Pleistocene peneplane 33

INDEX—Continued

Page

Pontotoc Hills equivalent to High Ridge cuesta ... 42
Prairie Bluff, angular unconformity at ... 126
Prairie Bluff chalk, description of ... 26
in Bullock County ... 118
in Crenshaw County ... 114
in Marengo County ... 110
in Montgomery County ... 116
in Sumter County ... 107
Prismatic calcite crystals, zone of ... 84, 85, 93
Providence sand, description of ... 26
physiographic expression of ... 42
Providence-Cusseta contact ... 97
Providence-Ripley contact ... 121, 125

R

Ripley formation, angular unconformity with Prairie Bluff chalk ... 26
bentonite in ... 112-114
correlation of ... 127
definition of ... 102
in Barbour County ... 119-125
in Bullock County ... 117-119
in Crenshaw County ... 114
in Dallas County ... 111
in Lowndes County ... 112-114
in Marengo County ... 110
in Montgomery County ... 113, 115-117
in Sumter County ... 69, 104-108
intertonguing with Demopolis member of Selma chalk ... 108
lithologic character of ... 104
on Chattahoochee River ... 123
overlapped by Providence sand ... 119
physiographic expression of ... 40, 127
stratigraphic relations of ... 126
thickness of ... 125
type locality of ... 103
Ripley-Clayton contact ... 110
Ripley-Cusseta contact ... 99
Ripley-Prairie Bluff contact ... 107, 110, 114, 116-118
Ripley-Providence contact ... 121, 125
Ripley-Selma contact ... 109
Road metal, Arcola limestone used for ... 61
Russell County, Blufftown formation in ... 74, 77, 79-81, 86
Cusseta sand in ... 89
Enon cuesta in ... 37, 101
Sand Fort cuesta in ... 35, 88

INDEX—Continued

Page

S

Sand Fort cuesta, Blufftown formation in 88
  definition of 35
Saratoga chalk correlated with Demopolis member of Selma chalk 72
Sawyerville, section of Eutaw formation and Selma chalk near 52
Selma, section of Eutaw formation and Selma chalk near 52
Selma chalk, Arcola limestone member of, *see* Arcola limestone
  correlation of lower marly member of 56
  Demopolis member of, *see* Demopolis member of Selma chalk
  divided by E. A. Smith 18
  divisions of 48
  general relations of 25
  intertonguing with Blufftown formation 87
  lower marly member of 48
    in Dallas County 52
    in Greene County 50
    in Hale County 51
    in Lowndes County 53
    in Macon County 53
    in Pickens County 49
    lithologic character of 49
    physiographic expression of 31, 57
    stratigraphic relations of 54, 55
    thickness of 55
  restriction of 48
  type locality of 48
Selma-Eutaw contact 49-54
Selma-Ripley contact 109
Semmes, D. R., cited 21, 29, 55
Smith, E. A., discovery of phosphate by 49
  divisions of Selma chalk of 64
  physiographic divisions of 29
  work of 16-19
Smith, E. A., and Johnson, L. C., cited 34, 55, 58, 102
  division of Upper Cretaceous by 17
  quoted 51
Smith, E. A., Johnson, L. C., and Langdon, D. W., cited 48, 53, 80, 102
  quoted 40, 54
Snowdoun well, thickness of Selma in 55
Spann Hill, section exposed on 84
Sprague, Cusseta sand near 94
Spring Hill, topography near 40, 88
Sreshthaputra, Vija, work by 14
Stephenson, L. W., cited 19-21, 34, 48, 57, 72, 89, 92, 102-104, 127
  division of Ripley formation by 73
  Exogyra zones described by 19

INDEX—Continued

Page

Stephenson, L. W.—Continued
  quoted ... 73
  work by ... 13, 74
  and Monroe, W. H., cited ... 21, 58, 102, 103
Strata, Ripley formation exposed near ... 115, 116
Stratigraphic relations of Arcola limestone ... 63
  of Blufftown formation ... 86
  of Cusseta sand ... 99
  of Demopolis member of Selma chalk ... 70
  of Ripley formation ... 126
  of the Upper Cretaceous formations ... 23, 24
Structure, geologic ... 23, 46
Sumter County, Arcola limestone in ... 61
  Demopolis member of Selma chalk in ... 66, 67, 69
  faulting in ... 13, 46, 104-106, 108
  High Ridge cuesta in ... 41
  Ripley formation in ... 69, 104-108
  thickness of lower marly member of Selma chalk in ... 55
Suspension, topography near ... 88

T

Taylor marl, lower part, correlated with Blufftown formation ... 87
  lower part, correlated with lower marly member of Selma chalk ... 56
  Pecan Gap chalk member, correlated with Demopolis member of of Selma chalk ... 72
Terraces along major rivers ... 43
Texas, formations in, represented in Blufftown formation ... 81, 87
  formations in, represented in Demopolis member of Selma chalk ... 72
    represented in lower marly member of Selma chalk ... 56
  Nacatoch sand in, equivalent to Ripley formation ... 127
Thickness of Arcola limestone ... 63
  of Blufftown formation ... 86
  of Cusseta sand ... 99
  of Demopolis member of Selma chalk ... 69
  of lower marly member of Selma chalk ... 55
  of Ripley formation ... 125
  of the Upper Cretaceous formations ... 23
Thomaston, section near ... 110
Thornton, E. Q., cited ... 16, 54, 58, 112
  quoted ... 40
Tokio formation, upper part, correlated with Blufftown formation ... 88
  upper part, correlated with lower marly members of Selma chalk ... 56
Tombigbee River, terraces of ... 43
Troy cuesta, definition of ... 42
Tuomey, Michael, cited ... 15, 34, 51, 58
Tuscaloosa formation, description of ... 23
Tuskegee, section exposed near ... 82

INDEX—Continued

Page

U

Uchee, section exposed near 79
Union Springs, sections exposed near 83, 93
topography near 35-38, 88
Upper Cretaceous formations, general features of 23

V

Veatch, Otto, division of Ripley formation by 19, 73
cited 89, 102
Volcanic ash in Demopolis member of Selma chalk 68
in Ripley formation 114

W

Warrior River, terraces of 43
Water resources of Alabama 18
Water supply of Black Prairie belt 34
Webb, R. D., cited 63
Wenonah sand correlated with Demopolis member of Selma chalk 72
Wetumpka fault zone 46
White Oak Springs, exposures near 120
Winchell, Alexander, cited 16, 48
quoted 51
Withers, R. W., cited 15
quoted 58
Woodbury clay correlated with Blufftown formation 88
Woolridge landing, Cusseta sand at 89, 92